

ISSN 0970-3179



24/10/05
B. A.

Annals of Agricultural Research

New Series Vol. 25

March 2004

Number 1

Published by
The Indian Society of Agricultural Science

INDIAN SOCIETY OF AGRICULTURAL SCIENCE

(Reg. No. S-10231)

EXECUTIVE COUNCIL

<i>Patron</i>	:	M.S. Swaminathan
<i>President</i>	:	Panjab Singh
<i>Vice-Presidents</i>	:	N.N. Singh
	:	R.G. Dani
<i>Secretary</i>	:	R.C. Gautam
<i>Joint Secretary</i>	:	D.S. Mathur
<i>Treasurer</i>	:	B.N. Mishra
<i>Past Presidents</i>	:	M.V. Rao, Prem Narayan,
	:	K.L. Chadha, R.B. Singh

COUNCILLORS

<i>East Zone</i>	<i>West Zone</i>
L.M. Garnayak, Orissa	M.V. Savani, Gujarat
A.K. Patra, Orissa	V.N. Waghmare, Maharashtra
<i>North Zone</i>	<i>South Zone</i>
N.K. Sekhon, Ludhiana	B.N. Reddy, Hyderabad
D.K. Pachauri, New Delhi	H.V. Nanjappa, Bangalore
<i>Central Zone</i>	
H.S. Yadav, M.P.	A.K. Pandey, U.P.

EDITORIAL BOARD

Editor-in-Chief : S.K. Mishra

Editors :

<i>Crop Improvement:</i>	<i>Resource Management:</i>	<i>Crop Protection :</i>	<i>Basic Sciences:</i>	<i>Social Sciences:</i>
B. Sharma	R.K. Rai	Amerika Singh	R.K. Katiyar	R.P. Singh
P.K. Singh	A.K. Dahama	Pratibha Sharma	Rajender Parsad	Poonam Sharma
A.K. Singh	B.G. Shivakumar	Kirti Sharma	G.C. Srivastava	Prem Lata Singh
R.L. Misra	R.N. Garg	Chitra Srivastava	S.M.S. Tomar	A.K. Das
Rajeev K. Sharma	S.K. Singhal	Anil Sirohi	M.K. Rana	Suresh Pal

All correspondences should be addressed to **Dr. R.C. Gautam, Secretary, Indian Society of Agricultural Science, Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012.**

Membership	India	Foreign Air Mail
Annual	Rs. 250	US\$40
Life	Rs. 2500	US\$500
Institutional	Rs. 850	US\$250

Discount to publishers 10%

Subscription may be sent by bank draft only. Payable to "Indian Society of Agricultural Science" at New Delhi. Out-station cheques are not accepted.

ANNALS OF AGRICULTURAL RESEARCH

CuE - H02950-3-PO 31894
(Organ of the Indian Society of Agricultural Science)

To promote inter-disciplinary research in the field of agriculture and provide a forum for expressing views on policies and programmes relating to agricultural development

CONTENTS

		Page
Study of genetic variability and correlation co-efficient analysis in midland landraces of rice	S.K. Sinha, A.K. Tripathi and U.K. Bisen	1
Feasibility of integration of plant resistance with plant population density and mode of insecticide application for the management of maize stem borer, <i>Chilo partellus</i> (Swinhoe)	P.S. Srinivas and V.P.S. Panwar	4
Effect of three carbamate pesticides and sewage sludge on the growth and trace metal concentration in vegetative parts of mustard and lentil	O.P. Bansal	9
Status of phosphorus in potato growing inceptisols of Agra district in Uttar Pradesh	S.P. Singh, S.K. Sharma, V. Singh, A. Sharma and A. Sharma	14
Effect of microclimate modification techniques for winter maize protection from low temperature	S.K. Dey and S.S. Hundal	19
Gene action for yield and its components in muskmelon (<i>Cucumis melo</i> L.)	S.S. Moon, V. K. Verma and A.D. Munshi	24
Assessment of genetic divergence in chickpea (<i>Cicer arietinum</i> L.)	L.J. Raval and K.L. Dobariya	30
Establishment, yield and water use efficiency of on-farm rainfed chickpea (<i>Cicer arietinum</i> L.) as influenced by tillage practices	R.S. Tripathi, Manish Kumar, N. Pandey, H.L. Sonboir and D. Pandey	35
Studies on soil microbial biomass P, labile P and phosphate activity under continuous intensive cultivation in an inceptisol	P. Santhy, K. Vijila, D. Selvi and M. Dhakshinamoorthy	38
Estimation of variability parameters for some quantitative characters in sesame (<i>Sesamum indicum</i>)	S.B. Singh and S.D. Singh	43
Earliness, yield and yield attributes in seven identified fusarium wilt resistant genotypes of muskmelon, <i>Cucumis melo</i> L.	Jaagrati Jain	46

p. 31894

Correlation and path analysis in a diallel cross of Indian bean	A.B. Bagade, D.U. Patel, S.C. Mali, R.M. Kshirsagar and P.B. Patel	49
Performance of wheat varieties under furrow irrigated raised bed-planting system (FIRBS) in sandy loam soil of north Bihar	Anil Kumar, S. Chowdhury, I.B. Pandey and O.R. Faruqi	52
Studies on time of anthesis and dehiscence in different genotypes of guava in winter and rainy season crops	Sanjay Singh	56
Balance sheet of nitrogen and phosphorus as influenced by integrated phosphorus management in soybean - wheat cropping system in southern Rajasthan	S.P.S. Tanwar, M.S. Shaktawat and A.K. Vyas	60
Identification of wide compatible and maintainer for WA-CMS lines in rice (<i>Oryza sativa</i> L.)	R. Thangapandian	65
Response of pearl millet (<i>Pennisetum glaucum</i> L.) hybrids to row spacing and nitrogen application	Satish Kumar, V.S. Kadian and R.C. Singh	68
Identifying potential pollinators for developing high yielding hybrids of pearl millet	V.K. Manga	71
Implications of organic manure, nitrogen and potassium applications in white yam (<i>Dioscorea rotundata</i> Poir) intercropped in coconut garden on nutrient balance of soil	G. Suja, V.M. Nair, R. Saraswathy and J. Sreekumar	76
Studies on peroxidase in jute bark tissue	Falguni Das, Satyakinkar Pal and Krishanu Chakrabarti	83
Effect of vermicompost and fertility levels on growth, yield and yield attributes of malt barley (<i>Hordeum vulgare</i> L.)	D.K. Roy, B.P. Singh and Paramjit Singh	87
Effect of insecticides on nitrifying bacteria in soil	Lata, A.K. Pandey and K.P. Narayan	92
Relative performance of sodicity tolerant rice varieties on (<i>Chloris gayana</i>) based lays under different doses of nitrogen	Banwari Lal and Manju Suman	95
Morpho-agronomic variability in synthetic hexaploid wheats derived from <i>Triticum turgidum</i> x <i>T. tauschii</i>	R.B. Ram and S.S. Singh	101
Correlation and path analysis of hybrids and parents in pearl millet	K.V. Unnikrishnan, Balzor Singh, Ramesh Singh, A.P.S. Verma and K.P. Singh	110
Wheat yield and soil bulk density response to tillage, residue and nitrogen management under rice-wheat system	Sandeep Kumar, D.S. Pandey and N.S. Rana	113

CONTENTS

iii

Forms of sulphur in alfisols and ultisols of Jharkhand in relation to soil properties	Brajendra and L.M. Shukla	118
Influence of components of inm on fruit yield and quality of acid lime in red calcareous soil	M.A. Aariff Khan, Hameedunnisa Begum and G. Swarajyalakshmi	124
Integrated use of CGA245704 and <i>Trichoderma Harzianum</i> on downy mildew supression and enzymatic activity in cauliflower	Pratibha Sharma, S.K. Sain, M. Sindhu and L.N. Kadu	129
Diallel analysis for components of genetic variation on some metric traits in black gram	Supriyo Chakraborty	135
Approximation of leaf area by using leaf dimensions in mango (<i>Mangifera indica</i> L.)	Achal Singh	139
Stability studies of inbred and their single crosses in maize (<i>Zea mays</i> L.)	Arun Kumar and N.N. Singh	142
Character association and path analysis of morphological attributes in green gram (<i>Vigna radiata</i> (L.) Wilczek)	G. Sreedevi and M. Reddy Sekhar	149
Effect of integrated nitrogen management on dry matter, yield attributes, yield and total N uptake	R.A. Jat and J.S. Balyan	153
Effect of variety, sowing time and integrated nutrient management on growht, yield attributes and yield of summer maize (<i>Zea mays</i>)	Sanjeev Malaiya, R.S. Tripathi and G.K. Shrivastava	155
Influence of integrated nutrient management practices on growth and yield of scented rice (<i>Oryza sativa</i> L.)	Santosh Kumar Jha, R.S. Tripathi and Sanjeev Malaiya	159
Effect of N,P,K and S combinations and microbial inoculants on nodulation, yield and NP content of soil after harvest of soybean [<i>Glycine max</i> (L.) Merrill]	B.L. Menaria and Pushpendra Singh	162
Effect of liming on available phosphorus and molybdenum status of the soil after soybean	R. Ebhin Masto, G. Bhupal Raj, P. Surendra Babu and K.S. Jayachandran	164
Genetic variability and association between plant height and base diameter in <i>Capsularis</i> jute	Nitendra Prakash, B.P. Pandey, S.P. Singh and P.K. Singh	167
Yield components of clusterbean as influenced by zinc and thiourea	Kavita Sharma, K.K. Jain and S.K. Sharma	169
Identification of trap crops for reducing of broomrape (<i>Orobancha aegyptiaca</i>) infestaion in the succeeding mustard (<i>Brassica juncea</i>)	Subhash Kuamr	172
Nutrient uptake and seed quality of spring sunflower (<i>Helainthus annuus</i> L.) in Mollisols of Uttranchal	M.S. Pal	174

STUDY OF GENETIC VARIABILITY AND CORRELATION CO-EFFICIENT ANALYSIS IN MIDLAND LANDRACES OF RICE

S.K. SINHA, A.K. TRIPATHI AND U.K. BISEN

RMD College of Agriculture & Research Station, Ambikapur-497001

ABSTRACT

Estimates of variability, heritability and genetic advance as well as correlation coefficients were worked out nineteen local midland landraces or rice of Surguja district along with IR36 for yield and its attributing characters. High genotypic coefficient of variation was observed in grain yield followed by test weight and panicle per plant. High heritability with high genetic advance was found for grain yield followed by test weight & panicles per plant. Significant positive genetic correlation was observed for panicle per plant and test weight with grain yield.

Key words : Genetic variability, midland, rice.

Availability of wide gene pool in the form of genetic diversity is a per-requisite for crop improvement. Surguja, the northern hill zone of Chhattisgarh is full of old traditional local landraces of rice which are being grown by the tribals since many decades. Therefore, the present investigation was undertaken to study the genetic parameters and correlation parameter in these local landraces.

MATERIALS AND METHODS

Nineteen medium duration local landraces of rice along with variety IR-36 as standard check were evaluated under rainfed transplanted condition. The material was sown in randomized block design with three replication during Kharif 1998 to 2000 at Zonal Agricultural Research Station, Ambikapur with full package of practices. Five competitive plants for each landraces in each replication were randomly taken to record observations on plant height (cm), tillers per hill, panicles per hill and panicle length (cm). Days to 50% flowering & days to maturity were computed on plot basis. Test weight (g) was recorded by weighing 1000 grains weight of each cultivars. Grain yield (kg) was recorded on plot basis and converted into q/ha. The data were subjected to statistical analysis (Panse and Sukhatme, 1967). The phenotypic, genotypic coefficients of variability, broadsense heritability

and expected genetic advance at 5% selection intensity were computed by using formulae suggested by Johanson *et al.* (1955). The phenotypic and genotypic correlation coefficients were calculated as per the method of Al-Jibouri *et al.* 1958.

RESULTS AND DISCUSSION

The genotypes showed a wide range of variability for all the characters under study (Table 1). However, the widest range of variability was recorded for plant height. Analysis of variance revealed highly significant differences among the cultivars for all the characters studied, indicating the presence of genetic variability among the cultivars. The magnitude of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the characters suggesting the influence of environmental force on the expression of these traits. The characters like plant height, tillers per hill, panicles per hill, test weight and grain yield showed high PCV and GCV estimates. Similar observation was obtained for plant height (Nath and Talukdar, 1997), for grain yield (Ravindra Babu 1996), for plant height and grain yield (Deb Choudhary and Das. 1998). Low PCV and GCV were obtained for days to 50% flowering and days to maturity being in conformity with the

Table 1. Range, mean and genetic parameters of variability in local midland landraces of rice

Characters	Range	Mean	Variance		Coefficient of variation		Broad sense heritability (%)	Genetic advance (% of mean)
			Genotypic	Phenotypic	Genotypic (%)	Phenotypic (%)		
Days to 50% flowering	69-85	76.30	19.61	19.90	5.80	5.85	98.51	11.87
Days to maturity	101-127	108.85	46.19	48.30	6.24	6.38	95.62	12.58
Plant height (cm)	70.1-128.4	107.97	244.27	277.48	14.48	15.43	88.03	27.98
Panicle length (cm)	18.2-28.2	21.61	5.67	6.07	11.02	11.40	93.29	21.92
Tillers per hill	7.4-16.2	10.22	2.41	3.48	15.19	18.25	69.32	26.05
Panicles per hill	5.6-15.3	8.85	2.05	2.83	16.18	19.01	72.42	28.36
Test weight (g)	15.5-28.0	21.54	13.98	14.71	17.36	17.81	95.01	34.86
Grain yield (q/ha)	15.4-40.7	26.73	44.77	50.89	25.04	26.69	87.97	48.97

Table 2. Correlation coefficients between yield and its attributes in rice

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Tillers per hill	Panicles per hill	Test weight (g)	Grain yield (q/ha)
Days to 50% flowering	1.000	0.818**	0.120	0.382	0.113	0.210	-0.158	0.120
Days to maturity	0.793**	1.000	0.031	0.347	0.404	0.554*	-0.214	0.302
Plant height (cm)	0.113	0.032	1.000	0.717**	-0.565**	-0.444*	-0.115	-0.016
Panicle length (cm)	0.360	0.428	0.647**	1.000	-0.332	-0.343	-0.348	-0.207
Tillers per hill	0.101	0.306	-0.440	-0.198	1.000	0.921**	-0.056	0.429
Panicles per hill	0.150	0.448*	-0.349	-0.095	0.897**	1.000	-0.014	0.606**
Test weight (g)	-0.151	-0.212	-0.125	-0.313	-0.014	0.011	1.000	0.505*
Grain yield (q/ha)	0.122	0.257	-0.007	-0.208	0.277	0.281	0.439	1.000

* P = 0.05, ** P = 0.01.

finding of Deb Choudhary and Das, 1998.

High heritability along with high genetic gain is beneficial for effective selection (Johnson *et al.* 1955). Days to 50% flowering and maturity exhibited high heritability estimates coupled with low values of genetic advance which indicated that high heritability values of these characters were probably due to non additive gene effects. Above result has also been reported by Deb Choudhary and Das 1998. High heritability associated with moderate genetic advance observed in test weight, plant height, panicles per hill and grain yield. Similar findings were reported for plant height, test weight & grain yield by Nath and Talukdar (1997), for panicles per plant & grain yield by Ravindra Babu (1996). Thus selection for these traits is likely to accumulate more additive genes leading to further improvement of their performance.

The genotypic and phenotypic correlation coefficients between grain yield and its

components are presented in Table 2. The grain yield showed significant positive correlation with panicles per hill and test weight at genotypic level. Supporting results were obtained for panicles per plant by Ravindra Babu (1996), for test weight by Reddy *et al.* (1997).

Plant height and significant positive correlation with panicle length, being conformity with the findings of Chauhan *et al.* (1993). On the other hand it had significant negative correlation with tillers per hill and panicles per hill. Reddy *et al.* (1997) reported significant negative association between plant height and earbearing tillers per plant. Panicles per hill had significant positive correlation with days to maturity and tillers per hill.

Therefore, emphasis should be given to plant having more number of panicles with high test weight in the breeding programme for the improvement of rainfed medium duration local landraces of rice.

REFERENCES

- Aljibouri, H.A., Miller, P.A. and Robinson, H.F. 1958. Genotypic, phenotypic and environmental variance in an upland cotton cross of interspecific origin. *Agron. J.*, 50 : 633-637.
- Chauhan, J.S., Chauhan, V.S. and Variar, M. 1993. Genetic variation and character association in rainfed upland rice. *Oryza*, 30 : 116-119.
- Deb Choudhary, P.K. and Das, P.K. 1998. Genetic variability, correlation and path coefficient analysis in deepwater rice. *Ann. Agric. Res.*, 19 (2) : 120-124.
- Johnson, H.W., Robinson, H.T. and Comstock, R.E. 1995. Genotypic and phenotypic correlations in soybean. *Agron. J.*, 47 : 477-482.
- Nath, N. and Talukdar, P. 1997 Genetic variability and correlation studies in segregating populations of indigenous scented X high yielding non-scented crosses of rice. *Oryza*, 34(2) : 91-93.
- Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for Agricultural workers, 2nd Ed., ICAR, New Delhi, pp. 152-161.
- Ravindra Babu V. 1996. Study of genetic parameters, correlations and path coefficient analysis of rice (*Oryza sativa* L.) under saline conditions. *Ann. Agric. Res.*, 17 (4) : 370-374.
- Reddy, J.N., De, R.N. and Suriya Rao, A.V. 1997. Correlation and path analysis in lowland rice under intermediate (0-50) water depth. *Oryza*, 34 (3) : 187-190.

FEASIBILITY OF INTEGRATION OF PLANT RESISTANCE WITH PLANT POPULATION DENSITY AND MODE OF INSECTICIDE APPLICATION FOR THE MANAGEMENT OF MAIZE STEM BORER, *CHILO PARTELLUS* (SWINHOE)

P.S. SRINIVAS* AND V.P.S. PANWAR

Division of Entomology, IARI, New Delhi-110012

ABSTRACT

Feasibility of integration of plant population density, mode of insecticide application with host plant resistance in maize was explored for the control of stem borer, recorded minimum infestation than Pusa composite-I. Higher plant population increased the borer damage. Whorl application of carbofuran 3G granules was effective in controlling the infestation. Efficacy of insecticide is more on resistant variety. A combination of resistant variety planted at normal plant population level protected minimize the pest in maize.

Key words : *Chilo partellus*, integrated pest management, plant population, plant resistance.

Chilo partellus in maize is particularly difficult to control largely because of the cryptic and nocturnal habits of the adult moth and protection offered by stem to the developing stages. Though many cultural practices were found effective, none could suppress the pest population below injury level when applied alone. The diversified methods of pest control in maize could be streamlined with in the existing components of integrated control of *C. partellus*. Host plant resistance either on its own or in conjunction with chemical and other cultural methods can be employed to reduce production costs, conserve natural enemies, preserve environment quality and reduce the rate of development of insecticide resistance pest strains (Adiksson and Dyck, 1980). An additional advantage of the use of resistant varieties is the increased efficacy of insecticides against the pest that feed on resistant plants. Van emden (1991) ascribed this to the effect of toxic substances or other unknown factors in resistant plants, which cause stress to, or induces nutritional inadequacies in the insect. Insecticide efficacy was increased against borer species on borer resistant line (Van der Berg et al., 1994). Therefore, a study was conducted to evaluate the feasibility of integration of plant population and mode of insecticide application with plant

resistance in maize against stem borer, *C. partellus*.

MATERIALS AND METHODS

A field trial was conducted during kharif season for two years, 1997 and 1998 with two maize varieties namely, a resistant variety Antigua Gr.L and a susceptible variety Pusa Composite-I. Each variety was grown at 2 population levels viz., normal (52800/ha) and high (66000/ha). Initially 2 seeds per hill were sown and after germination seedlings were uprooted accordingly to maintain the plant population in each plot. Modes of insecticide application consisted of foliar spray of endosulfan and whorl application of carbofuran 3G granules@ 1g and 1.25 g per m row in normal and higher plant population levels respectively at 13 days after sowing. Foliar spray was done with 0.1% Endosulfan 35 EC using a knap sack sprayer in the evening hours. Untreated control plot was kept for comparison. Recommended agronomic practices were followed to raise the crop. The experiment was laid out in a RBD (2×2×3 factorial) with 3 replications. Each plot consisted of 4 rows of 5m length each. Observations were recorded on dead heart, number of infested plants and predators (spiders) on 30 and 50 days after germination of the crop. All the species of spiders were counted. Yield at

*Mailing Add. : Scientist, NRC onion and garlic, Rajguru Nagar, Dist. Pune-410 505.

Table 1. Effect of mode of application of insecticides on the infestation including dead-hearts due to *C. partellus* in maize varieties grown at two plant population levels based on pooled data of *kharif*, 1997 and 1998

Mode of treatment	Average per cent infestation including dead-heart									
	Pusa composite-I (VI)			Antigua Gr.I (V2)			Mean plant population		Overall mean	
	Plant population level									
	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)		
Carbofuran (T1)	6.7 (24.74)	12.6 (33.21)	9.7 (28.97)	1.5 (11.82)	3.4 (17.31)	2.5 (14.57)	4.1 (18.28)	8.0 (25.26)	6.1 (21.77)	
Endosulfan (T2)	5.4 (21.67)	12.8 (32.94)	9.1 (27.31)	2.3 (14.46)	7.1 (24.85)	4.8 (19.65)	3.9 (18.06)	10.0 (28.90)	7.0 (23.48)	
Control (T3)	12.7 (33.44)	20.2 (41.96)	16.5 (37.07)	6.5 (22.15)	9.1 (26.94)	7.8 (24.55)	9.6 (27.79)	14.7 (34.45)	12.2 (31.12)	
Mean	8.3 (26.62)	15.2 (36.03)	11.8 (31.33)	3.4 (16.14)	6.5 (23.03)	5.0 (19.59)	5.9 (21.38)	10.9 (29.53)		
	(V)			(P)			(I)			
S.Em. ±	0.157			0.157			0.194			
C.D. (0.05)	0.46			0.46			0.57			
C.D. (0.01)	0.56			0.56			0.68			
	(VXP)			(PXT)			(VXI)			
S.Em.±	0.071			0.276			0.276			
C.D. (0.05)	0.21			0.81			0.81			
C.D. (0.01)	0.26			0.97			0.97			

Values in parentheses are arc sin transformed

Table 2. Effect of mode of application of insecticides on spider population in maize varieties grown at two plant population levels based on pooled data of *kharif*, 1997 and 1998

Mode of treatment	Average per cent infestation including dead-heart								
	Pusa composite-I (VI)		Antigua Gr.I (V2)				Overall mean		
	Plant population level								
	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)	
Carbofuran (T1)	10.66 (3.33)	11.50 (3.46)	11.10 (3.39)	11.33 (3.41)	12.33 (3.58)	11.83 (3.49)	11.00 (3.37)	11.91 (3.52)	11.46 (3.44)
Endosulfan (T2)	11.00 (3.38)	13.50 (3.73)	12.24 (3.56)	11.50 (3.46)	14.16 (3.82)	12.83 (3.64)	11.24 (3.42)	13.83 (3.78)	12.53 (3.60)
Control (T3)	11.83 (3.55)	15.50 (3.90)	13.66 (3.73)	12.00 (3.53)	13.67 (3.76)	12.83 (3.64)	13.25 (3.54)	14.58 (3.83)	13.26 (3.68)
Mean	11.16 (3.42)	12.88 (3.70)	12.32 (3.59)	11.61 (3.46)	13.38 (3.72)	12.49 (3.56)	11.38 (3.44)	13.44 (3.71)	
	(P)		(T)						
S.Em. $\pm$	0.020		0.23						
C.D. (0.05)	0.06		0.07						
C.D. (0.01)	0.07		0.09						
	(PXT)		(VXT)						
S.Em. $\pm$	0.034		0.034						
C.D. (0.05)	0.10		0.10						
C.D. (0.01)									

Values in parentheses are square root transformed

Table 3. Effect of mode of application of insecticides on the grain yield in maize varieties grown at two plant population levels based on pooled data of *kharif*, 1997 and 1998

Mode of treatment	Average per cent infestation including dead-heart								
	Pusa composite-I (VI)			Antigua Gr.I (V2)			Overall mean		
	Plant population level								
	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)	Mean			
	Normal (P1)	High (P2)	Mean	Normal (P1)	High (P2)	Mean			
Carbofuran (T1)	3.04	3.22	3.13	2.28	2.59	2.44	2.66	2.90	2.78
Endosulfan (T2)	3.25	3.48	3.37	2.50	2.50	2.50	2.88	2.99	2.93
Control (T3)	2.88	2.74	2.81	2.12	2.32	2.22	2.50	2.53	2.52
Mean	3.06	3.14	3.10	2.30	2.47	2.39	2.68	2.81	
	(V)			(I)					
S.E.m. $\pm$	0.04			0.05					
C.D. (0.05)	0.13			0.16					
C.D. (0.01)	0.18			0.22					

harvest was recorded and after shelling, grain weight at 15% moisture was recorded. Wherever necessary, suitable data transformations were made before statistical analysis. Pooled data were subjected to ANOVA using SAS Programme.

RESULTS AND DISCUSSION

Infestation including dead heart

A significant reduction in damage was observed in Antigua Gr.I in relation to Pusa composite-I. Antigua Gr.I recorded 5% whereas Pusa Composite-I recorded 11.8%. Increased susceptibility of larvae feeding on certain host plants ascribed to the effect of toxic substances or other unknown factors in resistant plants, which causes stress to or induces nutritional inadequacies in the insect (Painter, 1951; Van Emden, 1991). Irrespective of varieties, at higher plant population total infestation by the borer increased to 10.9% compared to plots with normal population that recorded 5.9%. Panwar and Sarup (1980) also reported similar results. Both the modes of insecticide application were offered good protection from stem borer. A substantial reduction of total infestation was recorded with application of carbofuran granules in plant whorl compared to foliar spray of endosulfan, which recorded 6.1 and 7.0% infestations respectively. The interaction of variety with plant population level and insecticide was pronounced significantly. The damage among the varieties differed significantly at both the population levels, the minimum being in Antigua Gr.I at normal population and maximum in pusa composite-I. However significantly low damage was observed in plots with Antigua Gr.I, which received whorl application of granules. The interaction effect of plant population levels with insecticide treatments was also found significant. The infestation increased with increase in plant population density in both the insecticide treatments and also in control.

Efficacy of both the modes of insecticide application increased on resistant variety. Carbofuran whorl application and endosulfan spray reduced damage to 3% and 5.6% damage on Antigua Gr.I compared to 13% and 9.5%

respectively on Pusa composite-I. Van der Berg et al. (1994) recorded few larval numbers of *C. partellus* on sorghum after insecticide application on resistant plants than that of susceptible plants.

Therefore the study suggest that a combination of resistant variety planted at normal plant population level protected through whorl application of Carbofuran granules forms the best combination to minimize the pest in maize.

Spider activity

Irrespective of species, spider population as such was recorded in maize. The varieties did not show any bearing on the spider activity. Plots with higher plant population density harboured significantly more spiders of 13.44/plot. When mode of application of insecticides was considered both the modes adversely affected the spider population. Among the two, whorl application of carbofuran granules significantly reduced the spider population compared to oiler

spray of endosulfan. Less number of spiders was recorded in plots with Pusa composite-I that were treated with granules and higher being in untreated plots of Pusa composite-I.

Grain yield

There was significant difference between varieties regarding grain yield. Plots with Pusa composite-I recorded significantly more yield than Antigua Gr.I. Both the insecticide treatments resulted in significantly higher yield than untreated control. Both the insecticide treatments were at par. Though the damage was less in Antigua Gr.I the yield was more in Pusa composite-I. This suggests that yielding ability of the variety also important besides resistance alone. Therefore if a good yielding variety that may be susceptible, is grown, pest management should be supported with other tactics such as population, insecticide application etc. Higher grain yield with carbofuran granules in plants whorls and endosulfan spray were also reported by Ganguly et al., (1997).

REFERENCES

- Adiksson, P.P. and Dyck. V.A. 1980. Resistant varieties in pest management systems. In. Breeding plants resistant to insects (Eds. F.G. Maxwell and P.R. Jannings), Wiley, New York, pp. 234-251.
- Ganguli, R.N., Choudhary, R.N. and Ganguli, Jayalaxmi, 1997. Effect of time of application of chemicals on management of maize stem borer, *Chilo partellus* (Swinhoe). *International Journal of Pest Management*, 43 (4) : 253-259.
- Mathur, L.M.L. 1994. Advances in insect pest management in maize. In. Trends in Agricultural Insect Pest Management. Dhaliwal and Ramesh Arora (Eds.). Commonwealth Publishers, New Delhi. pp. 113-161.
- Painter, R.H. 1951. Insect resistance in host plants. Mc. Millan, New York. pp. 520.
- Panwar, V.P.S. and Sarup, P. 1980. Exploring possibility of varied plant population levels of maize for the control *C. partellus* (Swinhoe). *J. Entomol. Res.*, 5 : 123-128.
- Pradhan, S. 1967. Strategy of integrated pest control. *Indian J. Ent.*, 29 (1) : 105-122.
- Van der Berg, J., Van Rensburg, G.D.J. and Van der Westhizen, M.C. 1994. Host plant resistance and chemical control of *C. partellus* and *Busseola fusca* (Fuller) in an integrated pest management system on grain sorghum. *Crop Protection*, 13(4) : 308-310
- Van Emden, H.F. 1991. The role of host plant resistance insect pest mismanagement. *Bull. Entomol. Res.*, 81 : 123-126.

EFFECT OF THREE CARBAMATE PESTICIDES AND SEWAGE SLUDGE ON THE GROWTH AND TRACE METAL CONCENTRATION IN VEGETATIVE PARTS OF MUSTARD AND LENTIL

O.P. BANSAL

Chemistry Department, D.S. College, Aligarh-202001

ABSTRACT

Experiments were made on illitic sandy loam of Aligarh district to study the growth and concentration of heavy metals Zn, Cu, Mn, Fe, Cr, Ni and Pb in different parts of plants of mustard and lentil in presence of different doses of three carbamate pesticides (I, II, III), anaerobically digested sewage sludge and their mixtures. The results indicate that lower concentration of pesticides ($0.2-0.3 \text{ g kg}^{-1}$ soil) and sewage sludge ($3-5 \text{ g kg}^{-1}$ soil) enhanced the plant growth and the yield of edible part as well. The activity of pesticides was in the order $\text{II} > \text{I} > \text{III}$. Mixtures of sewage sludge and pesticide (I, II, III) have almost the same effect as sewage sludge alone. The concentration of heavy metals were maximum in roots followed by stem and edible part. Concentration of heavy metals in mustard plants were more than in lentil.

Key words : Carbamate pesticides, illitic soil, mustard and lentil.

Agricultural chemicals such as fertilizers or pesticides are indispensable to modern agricultural activities. Although pesticides are highly beneficial to the crops grown but they must remain confined to root zone only. If a portion of applied pesticide leave the target soil compartment it can cause harmful effect to the environment. Volatilization, leaching to subsoil and ground water, runoff to surface water system and plant uptake are the major pathways through which agrochemicals may leave the root zone (Fury, 1996). The municipal sewage sludge is added in the soil to increase soil fertility and crop growth. The uptake of the metals present in sewage sludge by plants depends on soil pH and plant species (Jahiruddin & Cresser, 1993). As these soil contaminants modify the nutritional value of the food crops and their safety of human consumption (Khan et al., 1994), it was considered worthwhile to study the effect of different amounts of three carbamate pesticides, sewage sludge and combination of pesticide and sewage on the growth of mustard and lentil plants and on the concentration of trace metals viz. Zn, Cu, Mn, Fe, Cr, Ni and Pb in root, system and edible part.

MATERIALS AND METHODS

The physicochemical properties of illitic sandy loam soil of Aligarh district (depth 0-25 cm) and anaerobically digested sludge are given in Table 1. Green house experiments were conducted (year 2000-2001) in several glazed earthenware pots (60 cm $\times$ 45 cm) in triplicate. Each pot was filled with 5 kg of the soil, in three sets of experiments. In first set three carbamate pesticides (I, II, III viz. Oxamyl (I), S-Ethyl-(methyl carbamoyl) oxythioacetamidate (II) and N-phenyl-N-ethyl carbamoyl propyl carbamate (III) were applied at seven levels 0.0, 0.1, 0.2, 0.25, 0.3, 0.4 and 0.5 g kg^{-1} soil (t_1 to t_7) each separately. In the second set the soil samples were amended with 0, 1, 2, 3, 4, 5, 7.5 and 10 g kg^{-1} soil of dried and powdered sewage sludge in presence of 0.3 g of three carbamate (t_1 - t_7) pesticides I, II, III separately. Pre-germinated seedlings of mustard (*Brassica campestris* cv. RLM 619) and lentil (*Lens esculenta* var. T-44), were planted in all the pots. The plant were watered to maintain requisite soil moisture. At maturity of plants shoot height, weight of shoot, root-length were measured. Total produce was collected too and weighed. These pots, including

blanks, were also amended with NH_4NO_3 , superphosphate and KCl. The concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb in root, stem and edible parts were estimated by atomic absorption spectrophotometer after digesting with $\text{HClO}_3 : \text{HClO}_4$ (in 1 : 4 mixture).

RESULTS AND DISCUSSION

Effect of different doses (t_1 to t_7) of three carbamate pesticides (I, II, III) sewage sludge and pesticide and sewage sludge on the growth of mustard and lentil plants are given in Table 2. An examination of data (Table 2) indicate that the crop growth of mustard plants in presence of different levels of pesticides I, II, III initially increases and then decreases. The increase in crop growth in presence of carbamate pesticides may be due to more microbial activity and transformation of unavailable nutrients to available nutrients and formation of more soil humic acid (Stevenson, 1982). Due to toxic effect of higher doses of the carbamate pesticides on the microorganisms (Bansal, 2002), the growth of plants and yield of edible part decreases. The crop yield of mustard in presence of different doses of sewage sludge increases upto 5 g of sewage sludge per kg soil and then decreases, the order of crop yield suggest that with the addition of micro and macronutrients (viz. sludge) the crop growth increases, while at higher concentration due to higher content of heavy metals there may be phytotoxicity which retards crop yield (Khan and Khan, 1983). The crop yield in presence of 0.3 g kg^{-1} soil of pesticide I and different doses of sewage sludge indicates that the availability of nutrients decreases considerably due to formation of complex between pesticide and metals, and/or nitrogen fixation by microbial activity, the yield in presence of 0.3 g kg^{-1} soil of carbamate pesticide II or III and different doses of sewage sludge was found more than in presence of sewage sludge only.

An examination of data of Table 2 reveals that phytotoxicity for lentil plants followed the order pesticide II > pesticide I > pesticide III. The shoot length, shoot weight and root length and yield of edible part was in the order $t_4 > t_3 > t_5 > t_2 > t_6 > t_7 > t_1$ for pesticide I; $t_5 > t_4 > t_6 >$

$t_3 > t_7 > t_2 > t_1$ for pesticide II and $t_4 > t_5 > t_3 > t_6 > t_7 > t_2 > t_1$ for pesticide III. The decrease with high concentration of pesticide may be due to active role played by pesticides on soil microbial state and enzymatic activity (Ross and Speier, 1985). The crop growth and yield of edible part of lentil in presence of different doses of sewage sludge increases initially then decreases. This decrease may be due to unavailability of nutrient at higher concentration of sewage sludge due to the formation of complex (Tu, 1995). The crop yield in presence of 0.3 g of pesticides I, II, III (separately) and different doses of sewage sludge per kg soil initially increases and then decreases and followed the same order as in presence of sewage sludge only.

The results of study indicate that in presence of carbamate pesticides the concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb increases significantly in root, stem and edible parts of both the studied crops. The maximum concentration of metals was in root followed by stem and then in edible part. The concentration of metals in both the crops was found in the range Zn 64-160; 52-130; 10-25; Cu 22-42; 14-28; 1.3-3.1; Mn 50-90; 42-60; 21-30; Fe 280-370; 216-300; 160-206; Cr 1.5-3.1; 1.3-2.1; ND-0.8; Ni 1-1.7; 0.6-1.0; 1.0-0.6 and Pb 1.8-2.3; 1.1-1.5; 0.3-0.6 (kg g^{-1} on dry basis) in root, stem and edible part respectively. The effect of different doses of three carbamate pesticides on metal concentration was in the order II>I>III. The concentration of metals in the crops ($\mu\text{g g}^{-1}$ on dry basis) was more in mustard than in lentil. The change in concentration of micronutrients with different doses of carbamate pesticides may be due to active role played by pesticides on soil microbial status (Adriano, 1991; Singhal et al., 1976). Previous studies by the author himself (Bansal, 2002) indicated that microbial population in presence of studied carbamate pesticides increase with the doses. The optimum effect was with 0.25 g kg^{-1} of pesticide I; 0.2 g kg^{-1} of pesticide II and 0.3 g kg^{-1} of pesticide III. Thereafter there was a decrease in the microbial population with the doses. The change in micronutrient concentration with different doses of pesticides was due to solubilizing effects (Anderson and Siman, 1991) with decrease in pH (8.6 to 8.05) and increase in EC (0.56 to 0.72 dS^{-1})

Table 1. Physico-chemical properties of illite sandy loam of Aligarh and anaerobically digested sewage sludge

Illitic Sandy loam		Sewage sludge	
Silt %	50.9	pH (1:2)	7.0
Clay %	17.0	EC (dSm ⁻¹)	2.0
EC (1:2) (dSm ⁻¹)	0.56	Organic carbon %	16.8
Cation exchange capacity (C mol (P ⁺) Kg ⁻¹)	18.0		
pH (1:2)	8.6	Total nitrogen %	2.56
Organic matter %	1.14	Na (mg kg ⁻¹)	18.0
Surface area (m ²)	32.2	K (mg kg ⁻¹)	10.6
Exchangeable (mg kg ⁻¹)			
Ammonium N	100	Total metals (mg kg ⁻¹)	
Nitrite N	46	Fe	1920
Nitrate N	80	Mn	712
Available (mg kg ⁻¹)			
P	3.2	Zn	620
K	143	Cd	3.8
DTPA Extractable (mg kg ⁻¹)		Pb	62
Cu	0.58	Cu	270
Cd	Traces	Cr	54
Ni	0.06	Co	28
Zn	0.76		
Mn	3.8		
Fe	16.2		
Pb	0.1		
Cr	0.1		

by lower doses. Higher dose of pesticides causes negative influence due to adsorption by soil minerals and reduction of biological activity.

In presence of different doses of sewage sludge the concentration of metals in different parts of crops increased with sewage sludge upto 3.0 g of sewage sludge per kg soil. The concentration of metals in roots, stem and edible parts of both the studied crops was more than in presence of pesticide. The concentration of metals was Zn 84-186; 52-150; 10-26; Cu 22-46; 14-32; 1.3-3.4; Mn - 50-116; 42-84; 21-34; Fe 280-436; 216-336; 160-222; Cr 1.5-3.5; 1.3-2.2; ND-0.7; Ni-1-1.7; 0.6-1.0; 0.1-0.4 and Pb 1.8-2.3; 1.1-1.5; 0.3-0.6 ($\mu\text{g g}^{-1}$ on dry basis) in root, stem and edible part respectively. It may be due to availability of more micronutrients of plants in

presence of sewage sludge. At higher concentration of sewage sludge the concentration of metals in crops decreased which may be due to the formation of metal complexes with soil (Parkpain et al. 1998). The concentration of metals in different parts of crops in presence of 0.3 g pesticide and different doses of sewage sludge per kg soil was almost same as in presence of sewage sludge only indicating that pesticides have no appreciable effect on availability of nutrients from sewage sludge.

From the above results it can be inferred that different doses of carbamate pesticides, sewage sludge and their mixture influenced the growth, yield of edible part and concentration of Zn, Cu, Mn, Fe, Cr, Ni, Pb in different parts of mustard and lentil plants.

Table 2. Effect of different amounts of three carbamate pesticides, sewage sludge and sewage sludge and carbamate pesticides on the growth of mustard and lentil plants

Treatment	Addenda g kg ⁻¹ soil	Mustard				Lentil				Addenda g kg ⁻¹ soil				Mustard				Lentil			
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
t ₁	0.0	68.6	6.3	21.0	46	22.0	3.5	13.0	56	0.0	68.5	6.4	20.6	41	21.0	3.4	12.6	50			
t ₂	0.1	66.0	6.2	22.0	54	24.5	3.8	14.5	62	1.0	66.3	5.1	19.8	60	23.3	3.5	13.3	82			
t ₃	0.2	74.0	6.6	23.1	72	28.6	4.0	16.0	60	2.0	54.6	5.6	17.4	63	25.6	4.0	14.6	76			
t ₄	0.25	76.6	6.8	24.6	86	26.2	4.2	16.2	74	3.0	55.0	5.7	17.5	95	29.0	4.2	15.8	88			
t ₅	0.3	76.0	6.4	22.1	94	28.1	3.8	15.6	70	5.0	55.6	5.8	18.0	100	28.2	4.2	15.4	86			
t ₆	0.4	75.6	5.9	20.9	96	26.0	3.6	15.0	60	7.5	55.2	5.6	18.2	80	26.1	4.0	15.0	80			
t ₇	0.5	78.2	6.0	23.8	86	24.0	3.4	13.0	60	10.0	57.2	5.7	18.8	69	20.6	3.7	13.0	46			
Carbamate pesticides (II)																					
t ₁	0.0	68.6	6.3	21.0	46	22.0	3.5	13.0	56	0.0	72.3	6.8	22.8	81	24.4	3.6	13.4	56			
t ₂	0.1	69.3	6.7	22.2	56	25.0	3.7	14.2	66	1.0	68.6	6.6	22.4	66	26.6	3.7	14.7	69			
t ₃	0.2	72.4	7.2	23.6	78	26.6	3.7	15.8	27	2.0	64.3	6.5	21.6	78	29.8	4.2	16.2	76			
t ₄	0.25	66.6	6.0	23.6	88	28.8	3.9	16.1	78	3.0	60.1	6.4	20.0	60	27.25	4.2	15.4	70			
t ₅	0.3	67.8	6.7	22.1	86	30.2	4.0	16.6	84	5.0	54.2	6.0	18.9	50	26.0	4.0	15.3	66			
t ₆	0.4	66.6	6.5	22.6	92	27.4	3.8	16.0	77	7.5	51.6	5.8	18.4	36	26.0	4.0	15.3	60			
t ₇	0.5	66.6	6.5	22.4	820	25.2	3.6	15.4	80	10.0	45.2	5.1	16.6	36	25.1	3.9	15.1	52			
Carbamate pesticides (III)																					
t ₁	0.0	68.6	6.3	21.0	46	22.0	3.5	13.0	56	0.0	69.8	7.1	23.0	76	21.4	3.7	13.5	58			
t ₂	0.1	70.6	6.6	22.4	58	24.6	3.7	13.8	62	1.0	72.6	7.3	23.6	92	25.0	3.9	14.5	64			
t ₃	0.2	72.4	7.0	23.0	80	25.8	3.8	14.6	69	2.0	74.8	7.2	23.8	116	27.0	4.0	15.0	72			
t ₄	0.25	72.0	7.0	23.2	76	27.6	4.0	15.4	77	3.0	76.6	7.6	24.6	134	29.0	4.1	15.8	66			
t ₅	0.3	73.6	7.1	23.6	8	27.4	4.0	15.0	80	5.0	63.2	6.8	21.8	120	28.1	3.9	16.0	60			
t ₆	0.4	72.8	7.0	23.0	84	27.0	3.8	15.3	77	7.5	65.8	6.8	22.9	111	27.2	3.7	15.0	52			
t ₇	0.4	72.0	7.0	23.0	74	28.0	3.3	14.8	84	10.0	56.2	6.0	20.0	99	20.0	35.0	14.0	44			
0.3 g Carbamate pesticides (III) + sewage sludge																					
t ₁	0.0	72.0	7.6	24.0	80	21.6	3.7	14.0	52												
t ₂	1.0	75.0	7.8	25.2	100	23.0	3.9	14.2	66												
t ₃	2.0	78.0	8.0	25.6	120	27.3	4.2	14.5	88												
t ₄	3.0	84.0	8.0	26.0	118	28.6	4.2	15.0	100												
t ₅	5.0	72.0	7.6	25.1	100	25.0	4.1	14.1	74												
t ₆	7.5	64.0	7.1	23.4	92	22.0	3.7	14.0	73												
t ₇	10.0	64.0	7.0	23.4	73	19.4	3.5	13.5	116												

A = Shoot height (cm); B = Shoot weight (g); C = Root length (cm), D = Total weight of edible part (g)

REFERENCES

- Andersson, A. and Siman, G. 1991. *Acta Agric. Scand.*, **15**, 611.
- Andriano, D.C. 1991. Water, air and soil pollution, **57 & 58**, 331.
- Bansal, O.P. 2002. *Journal Indian Chem. Soc.* **79** (8) : 671.
- Fury, M. 1996. *J. Environ. Qual.* **25** : 25.
- Jahiruddin, M. and Cresser, M.S. 1993. *Journal Indian Sic. soil Sci.*, **41** : 684.
- Khan, S.U. and Khan, N.N. 1983. *Plant and Soil*, **74** : 387.
- Khan, H.R., Rahman, S., Hussain, M.S. and Adachi, T. 1994. *Soil Sci. Plant Nutr.*, **40** : 231.
- Parkpain, P., Sirisukhodam, S. and Carbonell-Barrachina, A.A. 1998. *Environ. Sci. Health A*, **33**, 573.
- Ross, D.J. and Speir, T.W. 1985. *Soil Biol. Biochem.*, **17** : 123.
- Singhal, J.P., Khan, S.U. and Bansal, O.P. 1976. *Journal Ind. Chem. Soc.*, **53** : 189.
- Stevenson, F.J. 1982. *Humus Chemistry, Genesis Composition reaction*, John Wileys and Sons, New York.
- Tu, C.M. 1995. *J. Environ. Sci. Health*, **B3** : 289.

STATUS OF PHOSPHORUS IN POTATO GROWING INCEPTISOLS OF AGRA DISTRICT IN UTTAR PRADESH

S.P. SINGH¹, S.K. SHARMA¹, V. SINGH, A. SHARMA² AND A. SHARMA¹

*Department of Agricultural Chemistry and Soil Science
Raja Balwant Singh College, Bichpuri Agra
Uttar Pradesh-283105*

ABSTRACT

Surface soils (0-15 cm) and potato samples collected from potato growing inceptisols of Agra district of Uttar Pradesh, were analysed for E.C., pH, CaCO₃, organic carbon, available and total phosphorus in soil and P.K. & S. in potato tuber. The available and total form of phosphorus in soil samples ranged from 3.2 to 18.8 ppm and 0.05 to 0.13 per cent with a mean of 11 ppm and 0.09 per cent respectively. In accordance with the limit of 10 kg P/ha, about 25 per cent soils under were found to be deficient in available phosphorus. The available P had a significant and positive relationship with organic carbon and total phosphorus content and negative with pH, EC and CaCO₃. Available phosphorus shared only 0.38 to 2.01 per cent of the total phosphorus. The phosphorus content in potato tubers varied from 0.18 to 0.39 per cent with an average value of 0.25 per cent. The range of potassium content in potato tubers varied from 1.05 to 1.90 per cent with an average value of 1.48 per cent. The sulphur content in potato tubers ranged from 0.14 to 0.39 per cent with an average value 0.27. The soil available phosphorus was found to have significant and positive relationship with potato phosphorus.

Key words : Phosphorus, potato, status.

Phosphorus is one of the major plant nutrients most often limiting crop growth in many soils. In the soils of India available P is generally medium to low. A knowledge of various forms of phosphorus present in soil and conditions under which they become available is a pre-requisite in assessing the phosphorus nutrition of plants. Much of the phosphorus in soil solution is present in the inorganic forms, since different P fraction have different solubilities and the amount of each depends on various soil characteristics (pH, CaCO₃, organic carbon, clay content etc.), the availability of soil phosphorus should largely depend on the total phosphorus present and soil characteristics. The present study was carried out to investigate and assess the status of P in soils and potato tuber in Agra district of Uttar Pradesh.

MATERIALS AND METHODS

Surface soils (0-15 cm depth) were collected from potato growing 6 tehsil fields of Agra districts of Western Uttar Pradesh. The sites selected for this study fairly cover the potato growing areas of this district. One hundred fifteen (115) samples of potato tubers were collected from the district under study from where soil samples were also collected. The soils were analysed for pH, E.C., CaCO₃, Organic carbon, available P and total P content in the following standard procedure (Jackson 1967).

The available phosphorus content of soils was extracted with 0.5 N NaHCO₃ (8.5 pH) Olson's et al. (1954). Total phosphorus was extracted by digestion with perchloric acid (60%) (Jackson, 1967). The potato tubers were analyzed for phosphorus, potassium and sulphur. The tubers after drying were digested with di-acid mixture (HNO₃, HClO₄ 4:1) (Johnson and Ulrich 1959) and analyzed for P by ammonium

¹Nagaland University, SASRD, Campus : Medziphema, Dist. Dimapur (N.L.)-797 106.

²ICAR, Research Complex for N.E. Region, Jarnapan, Dist. Dimapur (N.L.)-797 106.

molybdate vanadate by (Chapman and Pratt, 1961). Sulphur was determined by turbidimetric method (Chesnin and Yien, 1951), and potassium by Flame Photometer.

RESULTS AND DISCUSSION

Phosphorus status in Potato soils

General properties of Potato growing soils : The results of soil analysis pertaining to some physico-chemical properties of potato soils (Table 1), are discussed below :

pH : Potato growing soils of Agra district of Uttar Pradesh were near neutral to alkaline in reaction, the variation in pH being from 7.1 to 8.8 in Agra soils, 7.4 to 8.8 in Bah soils, 7.6 to 8.9 in Etmadpur soils, 7.6 to 8.6 in Fatehabad soils, 7.4 to 8.8 in Kheragarh soils and 7.5 to 8.5 in Kiraoli soils. The soils of Kheragarh tehsil had relatively higher pH values than the soils of other tehsil of the district.

Electrical conductivity : The EC of the soil water suspension (1:2.5) ranged between 0.06 and 0.41 dS/m. The ranges of variation within the soils of tehsils of Agra district viz. Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli were from 0.07 to 0.40, 0.10 to 0.30, 0.09 to 0.39, 0.09 to 0.33, 0.06 to 0.41 and 0.08 to 0.35 ds/m respectively. The soil samples from Etmadpur tehsil contained relatively higher concentration of soluble salts as compared to soils of other tehsils of the district.

Calcium Carbonate : Calcium carbonate content was invariably present in all the soils studied. The range of variation in this soil constituent was however, the largest among all the physiochemical attributes studied. The soils of Agra district on an average contained 1.4 per cent CaCO_3 . The average of variation within the soils of Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli tehsils were from 0.5 to 4.0, 0.5 to 3.5, 0.5 to 4.0, 0.5 to 3.0, 0.5 to 3.0 and 0.5 to 3.5 per cent respectively. In general the soils of Etmadpur were more calcareous than the soils of remaining tehsils of the district.

Organic Carbon : Organic carbon content in these soils, in general, may be considered low as most of them were found to contain less than 0.5 per cent. The amount of organic carbon content ranges from 0.35 to 0.63, 0.41 to 0.56, 0.36 to 0.59, 0.35 to 0.54, 0.30 to 0.57 and 0.39 to 0.61 per cent in the soils of Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli tehsils of the Agra district, respectively. Among the soils of different tehsils, Fatehabad soils were found to contain relatively lower amounts of organic carbon than the soils of other tehsils of this district.

Phosphorus status of soils : The status of total and available phosphorus in potato growing soils of Agra district are presented in table 2.

Total phosphorus : The total phosphorus content of potato growing soils of Agra district ranged

Table 1. Physico-chemical characteristics of potato growing soil of Agra district

Tehsils	No. of samples	pH	E.C. (dS/m)	Ca_2CO_3 (%)	Organic carbon(%)
Agra	40	7.1-8.8	0.07-0.40 (0.2)	0.5-4.0 (1.3)	0.35-0.63 (0.51)
Bah	10	7.4-8.8	0.10-0.30 (0.22)	0.5-3.5 (1.3)	0.41-0.56 (0.48)
Etmadpur	15	7.6-8.9	0.09-0.39 (0.25)	0.5-4.0 (1.5)	0.36-0.56 (0.48)
Fatehabad	15	7.6-8.6	0.09-0.33 (0.19)	0.5-0.3 (1.3)	0.35-0.54 (0.46)
Kheragarh	15	7.4-8.8	0.06-0.41 (0.24)	0.5-3.0 (1.4)	0.30-0.52 (0.47)
Keraoli	20	7.5-8.5	0.08-0.35 (0.21)	0.5-3.5 (1.4)	0.39-0.61 (0.51)

Figures in parenthesis indicate mean value.

Table 2. Status of total and available phosphorus in soils of Agra district

Tehsil	Total P (%)	Available P (ppm)	Available P $\times$ 100/Total P
Agra	0.05-0.13 (0.09)	3.8-18.8 (7.9)	0.42-1.74 (0.87)
Bah	0.05-0.11 (0.09)	3.2-12.8 (8.5)	0.55-1.42 (0.95)
Etmadpur	0.06-0.13 (0.10)	4.2-11.2 (6.6)	0.43-1.67 (0.74)
Fatehabad	0.05-0.11 (0.08)	4.4-12.0 (7.4)	0.38-1.50 (0.92)
Kheragarh	0.06-0.11 (0.09)	4.0-14.1 (7.4)	0.40-2.01 (0.91)
Keraoli	0.05-0.13 (0.09)	4.2-12.7 (8.1)	0.42-1.50 (0.86)

(Figures in parenthesis indicate the mean value)

from 0.05 to 0.13 per cent. The ranges of variation with in the soils of different tehsils varies viz. Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli were from 0.05 to 0.13, 0.05 to 0.11, 0.06 to 0.13, 0.05 to 0.11, 0.06 to 0.11 and 0.05 to 0.13 pre cent, respectively.

Thus, on an average the soils of Etmadpur tehsil were found to be relatively richer in total phosphorus as compared to soils of other tehsils of the district.

It is clear from the result that total P in potato growing soils of Agra district varied from 0.05 to 0.13 per cent with a mean value of 0.09 per cent. These values are fairly comparable to the results reported by Bhatia and Shankar (1982) for alluvial soils of Agra region. Singh and Omanwar (1987) for the soils of mid western Uttar Pradesh.

Available Phosphorus : The available P (Olsen's method) in the soil of Agra district varied between 3.8 and 18.8 ppm. The quantity of available phosphorus in the potato soils of different tehsils of Agra district viz. Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli ranged from 3.8 to 18.8, 3.2 to 12.8, 4.2 to 11.2, 4.4 to 12.0, 4.0 to 14.1 and 4.2 to 12.8 ppm, where as the mean values of available phosphorus for these soils were 7.9, 8.5, 6.6, 7.4 and 8.1 ppm, respectively.

The available phosphorus in potato soils of Agra district ranged from 3.8 to 18.8 ppm with a mean value of 7.9 ppm. The status of available P observed in the present study agreed well with the range of 5 to 21 ppm found by Kumar (1986) for the soils of Agra region.

The available P was reported to vary from 2.0 to 13.9 ppm in soils of Mizoram by Singh and Dutta (1987) reported 1.1 to 16.1 ppm available Phosphorus in soils of mid western Uttar Pradesh. About 25 per cent of soil samples fall in the category of low P status (<10kg/ha), 67.9 per cent in the medium category (10.0-24.6 kg P/ha) and 6.9 per cent samples belonged to high category (>24.6 kg P/ha.) irrespective to tehsils. Ghosh and Hasan (1979) reported a wide spread deficiency of P in Indian soils as soils in 98 per cent district have been reported to be low or medium in available phosphorus. According to More *et al.* (1979) most of the soils of Marathwada were found to contain low to medium available phosphorus.

Available Phosphorus/Total Phosphorus Ratio : The ratio of available P/total P showed variations in soils of Agra district. The maximum average value of this ratio was recorded in soils of Bah tehsil of the district. The ranges of this ratio in soils of Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli were from 0.42 to 1.74, 0.55 to 1.42, 0.43 to 1.67, 0.38 to 1.50, 0.40 to 2.01

and 0.42 to 1.50. According to Prasad et al., (1986) Olsen's P shared only 0.8 to 1.4 per cent of the total P. Singh and Omanwar (1987) reported 0.4 to 3.8 per cent of total P may be extracted by Olsen extractant.

Interrelationship between total and available Phosphorus : The wide difference in phosphorus content of soils and the correlation of coefficient between total and available phosphorus were significant ($r=0.53$) More et al. (1979) also reported significant and positive relationship between total and available P.

Relationship between soil characteristics and total and available Phosphorus : To study the effect of soil pH, EC, organic carbon and calcium carbonate on total and available phosphorus. The coefficient of correlation were worked out for all the soil samples collectively Table No. 3.

Soil pH was found to be inversely related with total and available phosphorus in potato growing soils of Agra district. However, the coefficient of correlation was non-significant in case of total phosphorus. The soil pH showed negative and significant relationship with available phosphorus. The results of present investigation are in accordance with the results of Singh and Omanwar (1987). The total phosphorus content of the soils did not show any significant relationship with soluble salt concentration in soils. However available phosphorus was found to be correlated significantly and negatively with E.C. total and available phosphorus was negatively correlated with calcium carbonate. But, this relationship was significant in case of available P only. More et al. (1979) reported similar relationship between CaCO_3 and phosphorus. The positive correlation

between organic carbon and total and available phosphorus indicates that the organic matter increases the availability of soil phosphorus. This results is inconformity with the findings of Bhan and Tripathi (1973).

Nutrient content in Potato tubers : Table No. 4, contains the data pertaining to P, K and S contents of potato tubers. The plant analysis data in respect of each of these nutrients are described separately.

Phosphorus : The phosphorus content in the potato tubers collected from the different tehsils viz. Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Kiraoli varied from 0.19 to 0.39, 0.18 to 0.36, 0.18 to 0.33, 0.18 to 0.32, 0.19 to 0.33 and 0.19 to 0.33 per cent, respectively. The mean values of phosphorus for these potato tubers were 0.26, 0.27, 0.23, 0.25, 0.24 and 0.27 per cent. Thus, on an average potato tubers collected from Bah and Kiraoli tehsils contained higher amount of phosphorus as compared to tubers collected from other tehsils of the district.

Potassium : The content of potassium in the potato tubers were in the ranges of 1.40 to 1.85, 1.44 to 1.90, 1.44 to 1.85, 1.45 to 1.85 and 1.45 to 1.85 per cent in Agra, Bah, Etmadpur, Fatehabad, Kheragarh and Keraoli tehsils respectively. The mean values of potassium in potato tubers of these tehsils were 1.68, 1.62, 1.65, 1.63 and 1.71. Thus, on an average potato tubers of Keraoli tehsil contained the higher amount of potassium as compared to potato tubers of other tehsils.

Sulphur : Among the different tehsils studied, Agra tehsil had the widest range of variation in sulphur content 0.14 to 0.39 per cent in potato tubers. The content of sulphur in potato samples

Table 3. Coefficient of correlation (r-value) between physico-chemical properties and forms of phosphorus in soils of Agra district

Physico-chemical properteis	Phosphorus	
	Total	Available
pH	-0.092	-0.679**
EC	0.066	-0.358**
CaCO_3	-0.101	-0.495**
Organic carbon	0.417**	0.749**

Table 4. Phosphorus, potassium and sulphur contents in potato tubers

Tehsil	Phosphorus (%)	Potassium (%)	Sulphur (%)
Agra	0.19-0.39 (0.26)	1.40-1.85 (1.68)	0.14-0.39 (0.29)
Bah	0.18-0.36 (0.27)	1.05-1.85 (1.62)	0.25-0.39 (0.30)
Etmadpur	0.18-0.33 (0.23)	1.44-1.90 (1.62)	0.22-0.35 (0.30)
Fatehabad	0.18-0.32 (0.25)	1.44-1.85 (1.65)	0.20-0.33 (0.28)
Kheragarh	0.19-0.33 (0.24)	1.45-1.85 (1.63)	0.20-0.38 (0.28)
Keraoli	0.19-0.33 (0.27)	1.45-1.85 (1.71)	0.20-0.39 (0.29)

(Figures in parenthesis indicate the mean value)

collected from Bah, Etmadpur, Fatehabad, Kheragarh and Keraoli tehsils varied from 0.25 to 0.39, 0.22 to 0.35, 0.20 to 0.33, 0.20 to 0.38 and 0.20 to 0.39 percent, respectively. The mean values of sulphur in potato tubers of these tehsils were 0.29, 0.30, 0.27, 0.28, 0.28 and 0.29 per cent

respectively.

Relationship between soil P and plant P : Linear correlation coefficient for plant and soil P was computed. The soil available P was found to have significant and positive relationship with plant P ($r=0.677$) growth and yield.

REFERENCES

- Bhatia, K.S. and Shankar, H. 1982. Distribution of Phosphorus in soils of the central alluvial tract of Uttar Pradesh. *J. of Indian Soc. of Soil Sci.*, 30 : 542-54.
- Chapman, H.D. and Pratt, P.A. 1961. Method of analysis for soils, plant & waters. University of California, Div. of Agricultural Sc., California.
- Chesnin, L. and Yien, C.H. 1950 : 'Turbidimetric determination of available sulphur in soil'. *Soil Sci. Soc. Amer. Proc.*, 15 : 149-151.
- Ghosh, A.B. and Hasan, R. 1979. Phosphorus fertility status of soils of India. *Fertilizer Bull. No. 12*. Vol. 155. 1-8.
- Jackson 1967. Soil chemical analysis. Prentice hall of Indian Pvt. Ltd. New Delhi.
- Johnson, C.M. and Ulrich, A. 1959 : Analytical methods for use in plant analysis. California Agricultural Exp. Stat. Bull. 766.
- Kumar, Sanjeev 1986. Soil phosphorus in Agra region soils. Inorganic Phosphorus fractions and their availability. A Ph.D. Thesis submitted to Agra Univ. Agra.
- More, S.D. Kachhare, K.G. and Varadi, S.E. 1979. Phosphorus availability as influenced by some important properties of vertisols of marathwada. *Bull. Indian Soc. of Soil Sci.*, 12 : 297-304.
- Olsen, S.R. Cole, C.V. watanake, F.S. and Dean, L.R. 1954. Estimation of available phosphorus in soils extraction with sodium bicarbonate. U.S.D.A. Cir. No. 939. 19.
- Prasad, S.N. Sahi, B.P. and Singh, S.P. 1986. Forms of P and response of wheat in vertisols of Bihar. *J. of Indian Soc. Soil Sci.*, 34 : 297-301.
- Singh, O.P. and Dutta, B. 1987. Phosphorus status of some hill soils of Mizoram in relation to pedogenic properties. *J. Indian Soc. of Soil Sci.*, 35 : 699-705.
- Singh, R. and Omanwar, P.K. 1987 : Phosphorus forms in some soils of mid western Uttar Pradesh I. Profile distribution and transformation of P. *J. Indian Soc. Soil Sci.*, 35 : 634-41.
- Singh, R. & Omanwar, P.K. 1987 : Phosphorus forms in some soils of mid weste Uttar Pradesh II. Soil available phosphorus. *J. Indian Soc. Soil Sci.*, 36 : 642-46.

EFFECT OF MICROCLIMATE MODIFICATION TECHNIQUES FOR WINTER MAIZE PROTECTION FROM LOW TEMPERATURE

S.K. DEY AND S.S. HUNDAL

Punjab Agricultural University, Ludhiana, Punjab

ABSTRACT

In a field experiment winter maize was grown following five treatments viz. Light irrigation when frost was expected; rice straw mulch; over head plastic cover and control. Morning as well as afternoon soil temperatures at 5cm depth were highest under polythene mulch followed by overhead plastic cover and straw mulch. Soil water status, xylem water potential and canopy temperature were most favourable under straw mulch treatment followed by polythene mulch and overhead plastic cover. Average air temperature at 10 cm height above the ground was 1.9°C higher than control during morning and 2.9°C higher during afternoon under the overhead plastic cover treatments. Maintenance of overhead plastic cover, polythene mulch and straw mulch during winter months resulted in 33.5, 31.5 and 31.0 percent higher grain yield compared to the control. Protective irrigation did not differ markedly from the control.

Key words : Winter maize, frost, minimum temperature, polythene cover, mulch.

Winter maize is a sensitive crop to low temperature. Army and Upper (1973) reported that when six or more leaves damaged due to low temperature, the crop yield was drastically reduced. A low temperature of -3 to 6°C increased the evaporation of water from leaf surface during early growth and markedly changed water status in plants. Stomatal activity was disrupted and dehydration of plants was increased due to increase in permeability of cell protoplasm. This results in a water deficit up to 32 percent in plants (Vinter, 1975). Keeping in view the damaging effect of low temperature directly on plant and indirectly on water availability for plant the present study was conducted to evaluate the simple microclimate modification techniques to protect winter maize from low temperature damage and provide favorable environment for minimizing the adverse effects on growth and yield of winter maize.

MATERIALS AND METHODS

A field study was conducted with winter maize (var Ganga-safed) sown on 2nd November 1998 at Ludhiana (30°56'N latitude and 75°52'E Longitude, 247 m above mean sea level) on a loamy sand soil. Five treatments namely : light

irrigation when frost was expected (protective irrigation), rice straw mulch, polythene mulch, overhead plastic cover and control was compared. Overhead plastic cover, polythene mulch was initiated on 11th December and was removed on 11th March. Protective irrigations were given on 13th January and 4th February. The crops were sown in ridges spaced 50 cm row to row and 20 cm plant to plant. Fertilizers @ 87.5 kg N, 60.0 kg P₂O₅ and 30 kg K₂O per ha were drilled and additional 35 kg N/ha was side dressed at 115 days after sowing.

Soil temperature at 5 cm depth was recorded with soil thermometers embedded in the center of the plots daily at 0730 and 1430 hours IST from 19-12-1998 to 12-03-1999. Similarly, air temperature was also recorded at 10 cm above the ground. Periodic measurements of canopy temperature and canopy-air-temperature difference were made at 1430 hours on selected clear days with the help of a hand held portable infrared thermometer. Soil moisture was measured thermo gravimetrically from soil depth of 0-15, 15-30, 30-60, 60-90 cm on selected days and the depths of water (cm) retained in the 0-90 cm-root zone were obtained. Leaf water potential measurements were made at 430 hours

with the help of a pressure chamber apparatus on the selected days when soil moisture observations were also taken. Two plants were sampled at random from each plot for dry matter accumulation. The samples were oven dried at 60°C before recording dry weight. The yield was recorded from the net plot at harvest on 22-04-99.

Climatic conditions during the early growing period for the months of December, January and February : The minimum air temperature for the months of December, January and February from 1970 to 1999 were analysed and it was observed that January was the coldest month for Ludhiana. On an average the month of December experienced minimum temperature below 4, 3, 2, 1 and 0°C for 8, 4.1, 1.5, 0.4 and 0.1 days respectively. But during December 1998 the minimum temperature did not go below 2°C however it was below 3°C and 4°C for 2 and 4 days respectively. On an average January experienced minimum temperature below 4, 3, 2, 1 and 0°C for 13.0, 8.9, 4.0, 1.6 and 0.5 days respectively. During 1999 January the temperature did not go below 3°C but it was below 4°C for 2 days only (Dey, 2000).

Soil temperature : Polythene mulch treatment recorded highest soil temperature and showed an average overall increase of 2.2°C over control in the morning and 2.8°C in the afternoon. Polythene mulch was followed by overhead plastic cover, which also recorded an average increase of 1.9°C over the control in the morning and 2.0°C in the afternoon. Straw mulch also increased the average soil temperature above control by 1.3°C in the morning but lowered the afternoon soil temperature below control by 3.0°C.

Air temperature : Overhead plastic cover treatment recorded the highest air temperature both during morning and afternoon. This increase was 1.9°C above control in morning and 2.9°C in the afternoon. The air temperature recorded for polythene mulch was also higher both in morning and afternoon compared to control but magnitude of the increase was less than that for the overhead plastic cover treatment.

Canopy temperature and Canopy - Air

temperature difference : Mulches (either straw or polythene) treatments resulted in lower canopy temperature and also more negative canopy - air temperature differences. This canopy temperature and canopy - air temperature differences trend correspond to those reported for soil water status under different treatments.

Soil moisture : General trend revealed maximum soil water storage under straw mulch followed by polythene mulch and overhead plastic cover treatment compared to control or protective irrigation treatment. The straw mulch conserved highest soil moisture because organic mulches reduce evaporation of water. Straw mulch also reduces evaporation by intercepting the solar energy that may reach the soil surface (Hillel et al., 1975). Improvement in the water use efficiency of crops through evaporation reduction by residues has been reported by Unger (1986), Sharma and Gupta (1987). Increase in soil moisture content with application of polythene mulch was reported by Kim et al., (1988), Bogle et al., (1989) and Decoteau et al., (1985).

Xylem water potential (XWP) : The mulches (either straw or polythene) treatment resulted in less negative water potential on all days. This xylem water potential trend corresponds to that reported for soil water potential on all days. This trend in XWP also agrees with that of canopy temperatures. Pandey et al., (1985) also observed a close correlation between XWP and canopy temperature of beans. Similar observations were reported for winter maize by Sumayao et al., (1980).

Dry matter accumulation of winter maize under different treatments : The periodic dry matter production in winter maize (Table 3) showed differences under different treatments. The total dry matter accumulation was maximum under overhead plastic cover at all stages of crop growth, which was followed by plastic mulch and straw mulch treatments. The dry matter production under protective irrigation was at par with the control treatments.

Yield and yield attributing characters

Number of cobs per plant : The cob bearing capacity is one of the most important crop yield

Table 1. Average soil temperature, Air temperature, Canopy temperature and Canopy - Air temperature differences under different treatments

Treatment	Temperature (°C)					
	Soil temperature at 5cm depth		Air temperature at 10 cm above the ground		Canopy temperature	Canopy Air
	0730 hr.	1420 hr.	0730 hr.	1430 hr.	0730 hr.	1430 hr.
Control	9.4	19.1	7.5	19.2	19.1	-2.7
Protective irrigation	9.5(+0.1)	19.0(-0.1)	7.5(0.0)	19.0(-0.2)	18.6	-3.1
Straw mulch	10.7(+1.3)	16.8(-2.3)	7.8(+0.3)	19.0(-0.2)	17.9	-3.5
Polythene mulch	11.6(+2.2)	21.9(+2.8)	7.9(+0.4)	19.6(+0.4)	18.2	-3.3
Overhead plastic cover	11.1(+1.7)	21.5(+2.4)	9.4(+1.9)	22.1(+2.9)	18.4	-3.0

Table 2. Soil water status in root zone and zylem water potential under different treatment

Treatment	Soil water retention (cm of water/90 cm root zone)				Xylem water potential (bars)			
	DAS			Mean	DAS			Mean
	47	62	101		47	62	101	
Control	11.1	14.0	14.1	13.0	-17.5	-17.5	-16.6	-17.3
Protective irrigation	11.0	13.9	15.6	13.5	-17.9	-17.2	-16.2	-17.1
Straw mulch	12.8	15.5	15.8	14.7	-16.7	-16.4	-15.3	-16.1
Polythene mulch	12.7	15.4	15.7	14.6	-16.9	-16.6	-15.7	-16.4
Overhead plastic cover	12.0	15.1	15.4	14.2	-17.2	-16.8	-15.9	-16.6

Table 3. Dry matter accumulation (g/m²) of winter maize under different treatments

Treatment	Days After Planting									
	45	60	75	90	105	120	135	150	165	At maturity
Control	34.8	46.3	93.8	134.1	242.7	364.5	534.8	742.9	800.3	845.2
Protective irrigation	32.8	45.3	95.3	143.2	249.4	374.5	539.1	752.7	807.1	851.9
Straw mulch	34.6	54.7	125.1	208.9	301.5	451.6	628.2	884.9	960.1	1009.2
Polythene mulch	35.1	59.4	144.9	216.6	309.3	464.3	652.3	896.0	997.4	1035.3
Overhead plastic cover	34.2	65.4	156.9	239.2	326.3	466.7	663.1	907.5	1003.3	1054.0
C.D. (P=0.05)								36.2	34.9	26.6

component in winter maize. The data with respect to number of cobs per plants is presented in Table 4. The plastic cover treatment produced maximum number of cobs per plant which was significantly higher than all other treatments. Polythene mulch and straw mulch treatments were at par, but significantly higher than

protective irrigation and control.

Test weight : (1000-grain weight) has a direct bearing on yield and quality of crop. The data presented in Table 4, clearly shows that plastic cover, polythene mulch and straw mulch had significantly higher test weight compared to

Table 4. Yield and yield attributing characters in winter maize under different treatments

Treatments	No. of cobs per plant	1000-seed weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
Control	0.52 ^a	203.6 ^a	3620 ^a	4779 ^a
Protective irrigation	0.52 ^a	203.7 ^a	3633 ^a	4789 ^a
Straw mulch	0.72 ^b	212.4 ^b	4742 ^b	5381 ^b
Polythene mulch	0.74 ^b	216.7 ^b	4761 ^b	5658 ^b
Overhead plastic cover	0.84 ^c	218.0 ^b	4833 ^c	5719 ^c
CD (0.05)	0.06	7.8	41.7	87.3

protective irrigation and control, Plant under plastic cover produced 7.05 per cent more test weight than control.

Stover yields : The data presented in Table 4, indicates that the stover yield was significantly increased under plastic cover and under mulches (straw and polythene) compared to control and protective irrigation. Stover yield under polythene mulch was at par with plastic cover treatment and both were significantly higher than the straw mulch treatment.

Grain yield : It is evident from Table 4 that the grain yield in maize was significantly increased by application of mulches (straw or polythene) compared to control and protective irrigation. However, the highest grain yield was obtained under overhead plastic cover which gave significantly higher yield than two mulch treatments. Similarly, higher yield with application of sugarcane trash mulch was

obtained by Jadav et al., (1995). Adeoye (1990) also got higher yields with application of grass straw. Struzia and Kromer (1988) reported that transparent mulch in maize produced higher yield than black or straw mulch. Similarly higher yield with application of polythene was observed by Nakui et al., (1995) and Jimbo (1998). These higher yields in terms of grain yield or Stover yield were due to better microclimate provided by these treatments.

CONCLUSION

On the basis of the results obtained in the present study it may be concluded that winter maize is a winter sensitive crop which require protection from low temperature and the use of overhead plastic is found suitable to check the damage. The polythene mulch and straw mulch treatments also provided protection from cold and resulted in better crop performance.

REFERENCES

- Adeoye, K.B. 1990. Timing of mulch application on maize at Samaru Northern Nigeria. Samaru J. Agric. Res. 7 : Effect of amount of mulch 57-66 (original not seen. *Abstract in Maize abstracts*, 9(1) : entry no 155, 1993).
- Army, D.C. and Upper, C.D. 1973. Example of the effects of early season frost damage on yield of corn. *Crop Sci.*, 139 (6) : 760-61.
- Bogle, C.B., Hartz, T.K. and Nunez, 1989. Comparison of subsurface trickle and furrow irrigation on plastic and bare soil for tomato production. *J. Amer. Soc. hort. Sci.*, 114 : 40-43.
- Decoteau, D.R., Kasperbaur, M.J. and Hunt, P.G. 1985. Mulch surface colour affects yield of fresh market tomatoes. *J. Amer. Soil. Hort. Sci.*, 114 (2) : 216-19.
- Dey, S.K. 2000. Studies of incidence of frost and protection of crops against low temperatures. M.Sc. Thesis, Punjab Agricultural University, Ludhiana.
- Hillel, D., Vanbovel, C.H.M. and Talpaz, H. 1975. Dynamic simulation of water storage in fallow soil as affected by hydrophobic aggregates. *Soil. Soc. Amer. Proc.*, 39 : 826-33.
- Jadav, B.S., Jadav, A.S. and Jadav, S.B. 1995. Effect of

- irrigation schedule, method and mulching on yield and nutrient uptake by maize (*Zea mays*) *Ind. J. Agr. Sci.*, **62** (7) : 472-75.
- Jimbo, N. Tokoroo, S. and Aoyagi, S. 1998. Temperature control method for sweet corn by forcing culture in plastic tunnel. *Tech. Bull.* 23 : 25-35. Chiba - ken Agricultural Experiment Station, Daizenochibba, Japan (original not seen. Abstract in Maize abstracts : entry no. 216, 1993).
- Kim, S.Y., Ryu, O.H. and Hatin, B.H. 1988. The effect of transplant polythene film mulch on the soil temperature, potato growth and yield of spring crop. Research report of rural development administration, Horticulture, Korea Republic 30 (2) 92-98 (original not seen. Abstract in potato abstracts 14 (10) : entry no. 1051, 1989).
- Nakui, T., Nonaka, K. Hara, S. and Shinoda, M. 1995. The effect of plastic mulch on the growth of maize plants and their TDN yield of silage in the Takachi district. *Bull. Hokkaido Nat. Arric. Exp. Sta.* 162 : 73-80 (original not seen. Abstract in Maize abstracts : 12(4) entry no. 216, 1993).
- Pandey, R.K., Herrera, W.A.T. and Pendleton 1981. Drought responses of grain legumes under irrigation gradient. 11. plant water status and canopy temperature. *Agron. J.*, **76** : 553-57.
- Sharma, R.A. and Gupta, R.K. 1987. Soil water evaporation from clay and sandy loam soils as influenced by straw and dust mulching. *Indian J. Soil Cons.*, **12** : 49-57.
- Struzia, A. and Kromer, K.H. 1988. Effect of costof mulching. *Amer. Soc. Agric. Eng.*, **88** : 31-34.
- Sumayao, C.R., Kanemasus, E.t. and Brakke, T.W. 1980. Using leaf temperature to assess evapotranspiration and advection. *Agric. Meteorology*, **22** : 153-66.
- Unger, P.W. 1986. Wheat residue management effects on soil storage and corn production. *Soil. Soc. Amer. Proc.*, **50** : 764-70.

GENE ACTION FOR YIELD AND ITS COMPONENTS IN MUSKMELON (*CUCUMIS MELO* L.)

S.S. MOON, V. K. VERMA AND A.D. MUNSHI

Division of Vegetable Crops
Indian Agricultural Research Institute
New Delhi-110012

ABSTRACT

A study of 28 F_1 hybrids of muskmelon (*Cucumis melo* L.) in a diallel set involving 8 parents showed overdominance for node number of first female flower, days to first female flower opening, days to first fruit maturity, number of fruits per plant, fruit weight, fruit diameter, flesh thickness, fruit cavity and average yield per plant except vine length. Non additive gene action was predominant for the inheritance of these characters. Low narrow sense heritability for these characters also indicated presence of non additive gene action. The predominance of non additive gene action and low narrow sense heritability for all the yield and its components except vine length suggested that heterosis breeding may be advantageous to get higher gain in muskmelon.

Key words : Diallel, gene action, yield, muskmelon.

Muskmelon (*Cucumis melo* L.) is cultivated extensively in India with an average productivity considerably low as compared to world average. Hence, there is an exigent need for the development of high yielding F_1 hybrids to improve productivity. It occupies a more prominent position due to its higher consumption as a dessert fruit, nutritive value and unique fruit qualities. A wide range of variability with respect to morphological, yield and fruit quality characters is available in this crop. In spite of this, meagre emphasis has been given to its genetical improvement and also the genetics (gene action) of yield and its components. Hence, an attempt was made to investigate the gene action for yield and its components in muskmelon.

MATERIALS AND METHODS

The experiment was carried out at the Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi during summer season of 1999-2000 to 2000-2001. Eight genetically diverse lines namely DVRM-1 (P_1), Pusa Madhuras (P_2), Punjab Rasila (P_3), M_3 (P_4), DMDR-1 (P_5), Durgapura Madhu (P_6), Ravi (P_7) and Hara Madhu (P_8) were crossed in 8×8 dialled fashion excluding reciprocals to get 28 F_1 crosses. The 28 F_1 hybrids along with their 8

parental lines were grown in a randomized block design with 3 replications. The crop was grown in rows of 2.5 m apart with spacing of 0.60 m between plants. The observations were recorded on five plants for ten economic important characters namely (1) Node number of first female flower (2) days to first female flower opening (3) days to first fruit maturity (4) number of fruits per plant (5) Fruit weight (kg) (6) Fruit diameter (cm) (7) Flesh thickness (cm) (8) Fruit cavity (cm) (9) Average yield per plant (kg) and (10) Vine length (cm). Diallel analysis was carried out on the lines by the method given by Hayman (1954) and Jinks and Hayman (1953).

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among all the parents and crosses studied for yield and its components in muskmelon. The range of mean values of F_1 hybrids were lower than those of the parents for node number of first female flower, days to first female flower opening, days to first fruit maturity and vine length. The range of mean values of F_1 hybrids were higher than those of the parents for number of fruits per plant, fruit weight, fruit diameter, flesh thickness, fruit cavity and average yield per plant. Among all

Table 1. Range of mean values of parents, F₁ hybrids and heterosis

	Node number of first female flower	Days to first female flower opening	Days to first fruit maturity	Number of fruits per plant	Fruit weight (kg)
Range of mean values					
Parents	2.80-10.50	38.74-62.12	76.16-94.13	2.34-3.59	0.53-1.14
F ₁ s	2.60-9.03	37.25-59.54	76.06-91.40	2.56-4.47	0.54-1.42
Range of heterosis % over					
TP	-	-	-	0.28-24.51	2.50-24.16
CC	-8.60 to -48.00	-0.03 to -11.58	-1.39 to -3.45	0.55 to 22.47	0.86 to 22.41
Number of heterotic crosses over					
TP	1	1	1	9	6
CC	4	4	2	6	6
Three top parents with their					
mean values					
	P ₆ (2.80)	P ₆ (38.74)	P ₃ (76.16)	P ₄ (3.59)	P ₅ (1.14)
	P ₁ (4.47)	P ₁ (42.02)	P ₁ (78.52)	P ₇ (3.25)	P ₄ (1.06)
	P ₇ (7.00)	P ₇ (45.59)	P ₆ (79.33)	P ₈ (3.13)	P ₈ (0.89)
Three top F ₁ hybrids with heterosis % over					
TP	P ₄ × P ₆ (-7.14)	P ₄ × P ₆ (-3.85)	P ₁ × P ₇ (-0.13)	P ₄ × P ₅ (24.51)	P ₄ × P ₅ (24.16)
	-	-	-	P ₂ × P ₈ (15.60)	P ₂ × P ₅ (14.85)
	-	-	-	P ₂ × P ₅ (11.97)	P ₅ × P ₇ (4.80)
CC	P ₄ × P ₆ (-48.00)	P ₄ × P ₆ (-11.58)	P ₁ × P ₇ (-3.45)	P ₄ × P ₅ (22.47)	P ₄ × P ₅ (22.41)
	P ₁ × P ₅ (-28.00)	P ₁ × P ₇ (-5.13)	P ₁ × P ₅ (-1.39)	P ₂ × P ₈ (13.70)	P ₂ × P ₅ (12.93)
	P ₁ × P ₇ (-30.00)	P ₁ × P ₅ (-1.99)		P ₂ × P ₅ (10.14)	P ₅ × P ₇ (3.45)

contd...

Table 1. contd...

	Fruit diameter (cm)	Flesh thickness (cm)	Fruit cavity (cm)	Average yield per plant (kg)	Vine length (cm)
Range of mean values					
Parents	7.33 to 14.00	1.77 to 2.83	6.13 to 7.93	1.25 to 3.77	131.07 to 263.76
F ₁ s	7.30 to 15.07	1.07 to 3.10	5.94 to 8.13	1.50 to 6.36	139.11 to 252.22
Range of heterosis % over					
TP	-	2.47 to 9.54	-3.10 to -3.26	5.29 to 68.57	-
CC	-	1.05 to 8.01	-1.87 to -14.92	0.24 to 50.35	3.87 to 6.99
Number of heterotic crosses over					
TP	1	2	2	9	0
CC	1	2	4	5	3
Three top parents with their mean values					
	P ₄ (14.00)	P ₄ (2.83)	P ₆ (6.13)	P ₄ (3.77)	P ₈ (263.76)
	P ₅ (13.30)	P ₅ (2.73)	P ₅ (6.63)	P ₅ (3.39)	P ₂ (239.77)
	P ₂ (12.72)	P ₂ (2.63)	P ₈ (7.03)	P ₈ (2.70)	P ₅ (216.76)
Three top F ₁ hybrids with heterosis % over					
TP	P ₄ × P ₅ (7.64)	P ₄ × P ₅ (9.54)	P ₂ × P ₆ (-3.26)	P ₄ × P ₅ (68.57)	-
	-	P ₄ × P ₇ (2.47)	P ₆ × P ₈ (-3.10)	P ₂ × P ₅ (56.34)	-
	-	-	-	P ₂ × P ₅ (11.97)	-
CC	P ₄ × P ₅ (6.13)	P ₄ × P ₅ (8.01)	P ₂ × P ₆ (-14.92)	P ₄ × P ₅ (50.35)	P ₂ × P ₈ (6.99)
	-	P ₄ × P ₇ (1.05)	P ₆ × P ₈ (-14.78)	P ₂ × P ₅ (25.30)	P ₄ × P ₈ (6.22)
	-	-	P ₃ × P ₈ (-2.01)	P ₂ × P ₈ (15.84)	P ₂ × P ₅ (3.87)

Table 2. Estimates of components of variation and various statistical parameters for different characters

Statistics	Node No. of first female flower	Days to first female flower opening	Days to first fruit maturity	No. of fruits per plant	Fruit weight (kg)	Fruit diameter s(cm)	Flesh thickness (cm)	Fruit cavity (cm)	Average yield per plant (kg)	Vine length (cm)
D	5.72** ±0.65	58.66 ±94.00	32.23** +5.39	0.12 +0.11	0.05** +0.01	4.40** +1.08	0.16 +0.10	0.30** +0.06	0.75 +0.52	2068.90** +93.52
H ₁	9.37** +1.49	88.65** +15.95	42.51** +12.40	0.81** +0.25	0.14** +0.03	10.85** +2.49	1.23** +0.23	0.61** +0.14	4.18** +1.20	1111.35** +214.99
H ₂	8.25** ±1.29	77.41** ±13.88	35.63** ±10.79	0.75** ±0.22	0.12** ±0.03	9.67** ±2.17	1.14** ±0.20	0.57** ±0.12	3.72** ±1.05	964.91** ±187.04
F	4.44** ±1.53	27.65 ±16.40	12.86 ±12.75	-0.05 ±0.26	-0.01 ±0.03	1.55 ±2.56	0.00 ±0.24	0.02 ±0.14	-0.53 ±1.24	-18.95 ±220.98
h ²	0.32 ±0.87	1.63 ±9.31	-3.32 ±7.24	0.17 ±0.14	0.01 ±0.02	0.67 ±1.46	0.60** ±0.13	0.07 ±0.08	0.58 ±0.70	19.97 ±125.44
E	0.06 ±0.22	2.14 ±2.31	7.61** ±1.80	0.03 ±0.04	0.21 ±0.45	0.11 ±0.36	0.01 ±0.03	0.05* ±0.02	0.05 ±0.17	98.14** ±31.17
(H ₁ /D) ^{1/2}	1.28	1.23	1.15	2.62	1.71	1.57	2.74	1.42	2.36	0.73
(H ₂ /4H ₁)	0.22	0.22	0.21	0.23	0.22	0.22	0.23	0.23	0.22	0.22
[(4DH ₁) ^{1/2} +F /(4DH ₁) ^{1/2} -F]	1.87	1.47	1.42	0.86	0.88	1.25	0.99	1.04	0.74	0.99
(h ² /H ₂)	0.04	0.02	-0.09	0.22	0.08	0.07	0.53	0.12	0.16	0.02
Heritability % (narrow sense)	48.6	45.75	34.92	10.75	22.99	31.11	11.49	28.02	13.23	57.6

*Significant at 5% level, ** Significant at 1% level.

eight parents, P_6 had the lowest node number of first female flower, days to first female flower opening and fruit variety, P_3 was observed to be the earliest for days to first fruit maturity. The highest number of fruits per plant, average yield per plant, maximum fruit diameter and flesh thickness were observed in P_4 , P_5 showed the highest fruit weight P_8 had the longest vine length. The best F_1 hybrids along with their superiority per cent over top parent and commercial check (Punjab Hybrid) for different characters included $P_4 \times P_6$ ($M_3 \times$ Durgapura Madhu) for node number of first female flower (-7.14 and -48.00), for days to first female flower opening (-3.85 and -11.58), $P_1 \times P_7$ (DVRM-1 $\times$ Ravi) for days to first fruit maturity (-0.13 and -3.45), $P_4 \times P_5$ ($M_3 \times$ DMDR-1) for number of fruits per plant (24.51 and 22.47), for fruit weight (24.16 and 22.41), for fruit diameter (7.64 and 6.13), for flesh thickness (9.54 and 8.01) and for average yield per plant (68.57 and 50.35) and $P_2 \times P_6$ (Pusa Madhuras $\times$ Durgapura Madhu) for fruit cavity (-3.26 and -14.92). None of the F_1 hybrid was found superior over top parent for vine length. The best F_1 hybrid along with its superiority per cent over commercial check for vine length was $P_2 \times P_8$ (6.99) (Table 1).

The values of dominance (H_1) were higher than additives for all the characters studied except vine length (Table 2). This shows the presence of non additive gene action (dominance) in the inheritance of all the characters except vine length. The estimates of mean degree of dominance (H_1/D)^{1/2} were much higher than unity showing overdominance for all the characters except vine length. The positive value of F for node number of first female flower, days to first female flower opening, days to first fruit maturity, fruit diameter and fruit cavity indicated more frequency of dominant alleles than recessive alleles in the parents. The negative

value of F for fruit weight, average yield per plant and vine length indicated more frequency of recessive alleles than dominant alleles in the parents. The proportion of genes with positive and negative effects ($H_2/4H_1$) in the parents was observed less than 0.25 for all the characters denoting asymmetry at loci showing dominance. The proportion of dominant and recessive genes [$(4DH_1) + F/(4DH_1) - F$] in the parent were higher or lower than one for all the characters except vine length (0.99) indicated asymmetry of genes distribution among the parents. The low narrow sense heritability (less than 0.5) for all traits except vine length indicated predominance of non additive gene action for expression of all characters except vine length. The results of the present investigation are in conformity with findings of More and Seshadri (1980) and Munshi and Verma (1998) in muskmelon, Doijode and Sulladmath (1985) and Yavasani (1997) in Pumpkin and Janakiram and Sirohi (1987) in bottlegourd.

The value of additive (D) was higher than that of dominance (H_1) for vine length indicates additive gene action for inheritance of this character. The estimate of mean degree of dominance (H_1/D)^{1/2} was less than unity and narrow sense heritability was found to be less than 0.5 for vine length confirmed the predominance of additive gene action. Hence selection can be exercised for the improvement of vine length in muskmelon. Similar result for vine length was observed by Sirohi and Choudhary (1983) in bittergourd.

In the present study, the preponderance of non additive gene action and low narrow sense heritability for all the yield and its components except vine length suggested that heterosis breeding may be advantageous to get higher gain in muskmelon.

REFERENCES

- Doijode, S.D. and Sulladmath, U.V. 1985. Genetics of certain fruit characters in pumpkin (*Cucurbita moschata* Poir). *Egypt J. Genet. and Cytol.*, **14**(1): 35-40.
- Hayman, B.I. 1954. The theory and analysis of diallel crosses. *Genetics*, **42**: 336-355.
- More, T.A. and Seshadri, V.S. 1980. Studies on heterosis in muskmelon (*Cucumis melo* L.). *Veg.*

- Sci., 7 (1) : 27-40.
- Munshi, A.D. and Verma, V.K. 1998. Note on gene action in muskmelon (*Cucumis melo* L.). *Veg. Sci.*, 25 (1) : 93-94.
- Janakiram, T. and Sirohi, P.S. 1987. Gene action in round fruited bottlegourd. *Veg. Sci.*, 14(1) : 27-32.
- Jinks, J.L. and Hayman, B.I. 1953. The analysis of diallel crosses. *Maize genet. Coop. Newsl.*, 27 : 48-54.
- Sirohi, P.S. and Choudhury, B. 1983. Diallel analysis for variability in bittergourd. *Indian J. Agril. Sci.*, 53(10) : 880-888.
- Yavasani, S.R. 1997. Heterosis, combining ability and gene action in pumpkin (*Cucurbita moschata* Duch. ex Poir). Ph.D. Thesis, IARI, Pusa, New Delhi-110 012.

ASSESSMENT OF GENETIC DIVERGENCE IN CHICKPEA (*CICER ARIETINUM* L.)

L.J. RAVAL AND K.L. DOBARIYA

Department of Agricultural Botany, College of Agriculture, GAU, Junagadh - 362 001 (Gujarat)

ABSTRACT

The genetic divergence measured by Mahalanobis' D^2 -statistic grouped 52 genotypes of chickpea into 15 clusters. The study revealed enormous diversity in the material as indicated by the wide range of D^2 -values. No parallelism was observed between geographic distribution and genetic diversity. The intercluster distances ranged from 8.29 between clusters IV and VIII to 37.53 between III and XIV. The different clusters were superior in respect of different characters. Clusters I showed high mean for biological yield per plant, while cluster VI had high mean number of seeds per pod. Clusters X and XII contained genotypes with higher mean seed yield per plant, number of primary branches per plant and harvest index. Cluster XIII was the best for higher plant spread and 100-seed weight. Cluster XIV showed the lowest values for days to flowering, maturity and plant height. Cluster XV presented high means for secondary branches, pods per plant and protein content. It will be fruitful to intercross the genotypes from clusters X, XIII and I with those of clusters XIV and XII for generation of promising derivatives and wide spectrum genetic variability for yield improvement in chickpea.

Key words : Chickpea, clusters, D^2 -values, genetic divergence.

Chickpea (*Cicer arietinum* L.) is the most important pulse crop of the country and is largely grown on marginal and submarginal lands of semiarid and arid tropics. The success of any breeding programme depends upon the availability of adequate genetic diversity. The major factor responsible for limited success in increasing the chickpea yield has been the narrow genetic base of the material available. Plant breeders are always interested in assessing the genetic divergence among the varieties or advanced breeding lines available with them so as to utilize them in directed breeding programmes. The diverse parents, when utilized in cross breeding programmes, are likely to produce a wide spectrum of variability and offer maximum chances of isolating transgressive segregants. Mahalanobis's (1936) D^2 -statistic is being used as an efficient tool in quantitative estimation of genetic diversity and for choice of appropriate parents in hybridization programme. The present study aims at the assessment of genetic diversity in a collection of 52 genotypes of chickpea.

MATERIALS AND METHODS

Fifty two genotypes of chickpea were sown in the rabi season of 2000-2001 in randomized block design with three replications at Pulse Research Station, GAU, Junagadh. Each entry was planted in a single row of 4.0 m length with a spacing of 30 × 10 cm. The observations were recorded on five randomly selected plants in each entry and in each replication on 13 component characters and the mean values were used for statistical analysis. Mahalanobis's (1936) D^2 -statistic was used for assessing the genetic divergence between the genotypes. The genotypes were grouped into a number of clusters by Tocher's methods as described by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the 52 genotypes for all the characters under study indicating the presence of ample variability among the genotypes. The D^2 -values between all possible 1326 pairs ranged from 12.05 between the genotypes GCP 101 and GCP 9516 to 1514.75 between CSJD 151 and BGD

Table 1. Grouping of 52 genotypes of chickpea in various clusters on the basis of D²-statistic

Cluster	Number of genotypes	Name of the genotypes	Origin/ source
I	14	GNG 469	Sriganganagar (Raj.)
		BG 256, BG 1086	IARI, New Delhi
		BGD 72	Dharwad (Karnataka)
		JSC 4, JSC 5	Sehore (M.P.)
		JG 975	Jabalpur (M.P.)
		KGD 1191, IPC 97-34	Kanpur (U.P.)
		WCG 97-23	Ludhiana (Punjab)
		CSJ 165, RSG 811	Durgapara (Raj.)
		BDNG 796	Badnapur (Mah.)
		JCP 27	Junagadh (Guj.)
		GCP 101, GCP 105, GCP 9516, GCP 9504, GCP 9605	Junagadh (Guj.)
II	11	ICCC4	ICRISAT, Patancheru
		BGD 98	Dharwad (Karnataka)
		CSJD 901	Diggi (Raj.)
		H 96-51	Hisar (Haryana)
		IG 290415	Indore (M.P.)
		SPBG 99-4	Bharari (U.P.)
		C 235	Ludhiana (Punjab)
III	6	CSJD 151	Diggi (Raj.)
		FG 712	Faridkot (Punjab)
		FG 712	Farodkot (Punjab)
		KGDM 1180	Kanpur (U.P.)
IV	2	H-95-123	Hisar (Haryana)
		BG 391	IARI, New Delhi
		GCP 9528	Junagadh (Guj.)
V	5	JG 315, JG 62	Jabalpur (M.P.)
		SAKI 9516	Sehore (M.P.)
VI	1	GCP 104, GCP 106	Junagadh (Guj.)
VII	2	PBG 126	Bhatinda (Punjab)
VIII	1	AKG 26	Rahuri (Mah.)
IX	1	PG 5	Pantnagar (Uttanchal)
X	2	Dahod yellow	Dahod (Guj.)
XI	2	WCG 97-112	Ludhiana (Punjab)
		Phule G-96=108	Rahuri (Mah.)
		GCP 103	Junagadh (Guj.)
XII	2	RAUG 3-1	Modipuram (T.N.)
		GCP 107	Junagadh (Guj.)
XIII	1	Phule G-95-126	Rahuri
XIV	1	IPC DB-933	Kanpur (U.P.)
XV	1	BGD 119	Dharwad (Karnataka)
	1	Vijay (Phule G 81-1-1)	Rahuri (Mah.)

The inter and intracluster distances are shown in Table 2. In general, intracluster distances were lower than the intercluster distances. Thus, the genotypes included within a cluster tended to diverse less from each other. The intracluster distances (D) ranged from 6.60 to 11.15 for clusters X and XI, respectively. The maximum intercluster distance (D) was observed between cluster III and XIV (D=37.53) followed by cluster VI and XIV (D=37.35). Thus, the clusters III and XIV were the most diverse, the intercluster distance between them being maximum. The intercluster proximity was maximum between cluster IV and VIII indicating that they were closely related. Intercluster distance is the main criterion for selection of genotypes using D²-analysis. The genotypes

Table 2. Average inter and intra-cluster distance ($D=\sqrt{D^2}$) values in chickpea

[illegible]

Table 2. Average inter and intra-cluster distance ($D=\sqrt{D^2}$) values in chickpea

Clusters	Seed yield/plant (g)	Days to 50% flowering	Days to maturity	Plant height (cm)	Plant spread (cm)	No. of primary branches /plant	No. of secondary branches /plant	No. of pods/plant	Biological yield/plant (g)	No. of seeds/pod	100-seed weight (g)	Harvest index (%)	Protein content (%)
I	7.35	56.45	96.86	43.38	42.52	2.03	3.54	33.36	18.28	1.11	22.18	40.56	21.26
II	4.65	57.03	97.18	38.80	39.32	1.69	2.89	28.04	11.86	1.21	14.63	39.07	21.74
III	4.48	67.00	106.06	41.29	40.80	1.83	3.37	25.22	11.75	1.29	15.14	37.99	21.61
IV	5.71	61.00	103.50	42.53	32.87	2.03	2.84	24.00	13.82	1.14	22.15	41.24	21.91
V	5.51	51.60	93.07	36.27	35.93	2.21	4.70	37.35	12.06	1.23	12.56	45.93	20.87
VI	4.21	67.00	105.67	42.07	41.73	1.13	2.47	22.53	13.85	1.69	12.82	30.20	24.07
VII	4.70	46.34	90.17	35.80	37.27	1.94	4.80	30.04	12.32	1.14	14.38	38.41	22.18
VIII	4.27	58.33	99.67	41.03	36.47	1.87	2.53	20.47	11.04	1.06	24.82	38.64	19.63
IX	5.24	54.67	93.33	39.13	36.93	1.87	4.07	29.67	13.93	1.31	12.50	37.70	24.29
X	8.77	51.84	92.34	41.07	34.97	3.07	5.15	38.57	17.87	1.11	21.72	49.23	20.46
XI	5.49	59.34	100.17	36.03	39.59	1.67	3.44	33.17	12.51	1.30	11.51	43.27	21.41
XII	7.28	45.50	90.17	40.73	39.37	2.54	5.03	29.57	15.32	1.15	23.29	48.27	23.96
XIII	7.03	62.00	103.00	46.40	43.60	1.93	3.07	22.33	18.23	1.07	29.20	38.64	24.40
XIV	5.47	37.67	86.67	33.90	30.20	1.87	5.13	27.00	13.24	1.15	17.57	41.07	23.18
XV	6.72	49.33	93.33	37.60	38.13	1.73	7.73	42.33	15.08	1.05	14.82	46.09	24.62
Mean	5.79	55.01	96.74	39.73	37.98	1.96	4.05	29.58	14.08	1.20	17.95	41.09	22.37
SEm±	0.35	2.10	1.57	0.87	0.94	0.11	0.36	1.66	0.62	0.04	1.41	1.26	0.41
CV %	23.30	14.81	6.28	8.48	9.56	21.87	34.66	21.68	17.18	13.32	30.51	11.89	7.14

belonging to the clusters separated by high statistical distance are genetically more divergent and could be used in hybridization programme for obtaining a wide spectrum of variation among the segregates. In this context, genotypes from cluster XIV (BGD 119) and cluster III (C 235, CSJD 151) and cluster VI (PBG 126) should be selected as parents in hybridization programme.

The cluster means for 13 characters are presented in Table 3. A wide range of variation for several characters among single as well as multi genotype clusters was observed which indicated that the different clusters were superior in respect of different characters. However, the differences among the cluster means were more conspicuous for number of secondary branches per plant, 100-seed weight, seed yield per plant, number of primary branches per plant and number of pods per plant which had contributed substantially to the total divergence as also reflected by their coefficient of variation. The present findings are in conformity with those obtained earlier in chickpea by Asawa *et al.* (1981), Sarvaliya and Goyal (1994) and Deshmukh and Patil (1998).

Cluster I contained genotypes with high biological yield per plant (18.28 g). This cluster also represented entries which had higher seed yield per plant (7.35g) and plant spread (42.52 cm). Cluster VI had high mean number of seeds per pod (1.69). Cluster X included genotypes with high mean seed yield per plant (8.77 g), number of primary branches per plant (3.07) and harvest

index (49.23%). Cluster X was also a good source for higher number of pods (38.57) and secondary branches per plant (5.15). Cluster XII contained genotypes with entry flowering (45.50 days) and maturity (90.17 days) as well as higher primary branches (2.54), seed yield per plant (7.28 g) and harvest index (48.27%) and can be regarded as a good source for earliness and higher mean seed yield per plant. Cluster XIII was the best source for higher plant spread (43.60 cm) and 100-seed weight (29.20g). This cluster also contained genotypes with higher biological yield per plant (18.23g) and protein content (24.40%). Cluster XIV with the lowest mean values for days to flowering (37.67 days), maturity (86.67 days) and plant height (33.90 cm) can be regarded as a useful source for earliness and dwarf plant types. Cluster XV presented high mean performances with regards to secondary branches per plant (7.73), pods per plant (42.33) and protein content (24.62%). Therefore, the selection and intercrossing of genotypes involved in these clusters would be useful for inducing variability in the respective characters.

Based on genetic diversity and excellence shown for agronomic traits, crosses between the genotypes of clusters X, XIII and I with the genotypes of clusters XIV and XII may produce promising derivatives with early maturity and better yielding capacity. Such intercrossing of genotypes may also lead to broad spectrum of favorable genetic variability for yield improvement in chickpea.

REFERENCES

- Asawa, B.M., Chadra, R.K. and Mathoo, V.K. 1981. *Indian J. Agric. Sci.*, **51** : 762-766.
- Bhatt, G.M. 1970. *Aust. J. Agric. Res.* **21** : 1-7.
- Dasgupta, T., Islam, M.O., Gayen, P. and Sarkar, K.K. 1987. *Expet. Genet.*, **3** : 15-21.
- Deshmukh, R.B. and Patil, J.V. 1998. *Madras Agric. J.*, **84** : 664-666.
- Katiyar, R.P. 1978. *Indian J. Agric. Sci.*, **48** : 451-454.
- Lal, D., Ram Krishna and Singh, G. 2001. *Indian J. Pulses Res.*, **14** : 63-64.
- Mahalanobis, P.C. 1936. *Proc. Natl. Inst. Sci.*, (India) **2** : 49-55.
- Mian, M.A.K. and Bahl, P.N. 1989. *Indian J. Genet.*, **49** : 119-124.
- Rao, C.R. 1952. *Advanced Statistical Methods in Biometrical Research*. John Wiley and Sons, New York.
- Sarvaliya, V.M. and Goyal, S.N. 1994. *Legume Res.*, **17** : 22-26.
- Yadav, S.P., Beohar, A.B.L. and Rao, S.K. 1991. *Agric. Sci. Digest*, **11** : 6-7.

ESTABLISHMENT, YIELD AND WATER USE EFFICIENCY OF ON-FARM RAINFED CHICKPEA (*CICER ARIETINUM* L.) AS INFLUENCED BY TILLAGE PRACTICES

R.S. TRIPATHI, MANISH KUMAR, N. PANDEY, H.L. SONBOIR AND D. PANDEY

Department of Agronomy, Indira Gandhi Agricultural University, Raipur-492 012

ABSTRACT

On-farm field experiment was conducted on mid land rainfed rice based cropping system during rabi 1999-01 at village Khatti, district Mahasamund, Indira Gandhi Agricultural University, Raipur to study the impact of ploughing intensity on establishment, productivity and moisture use efficiency of gram. Either once or twice ploughing of field and seeding of gram on the same day recorded significantly higher grain yield, straw yield and water use efficiency. Direct drilling of gram seeds registered lower yield. Line sowing of the crop accounted higher grain yield than broadcasting system.

Key words : Gram, yield, water use efficiency, tillage, on-farm.

In rainfed areas, soil moisture is the prime factor for good germination and successful rabi crops. The productivity of gram is very low in Chhattisgarh state. The reasons for low productivity of gram are : lack of irrigation, poor plant stand due to broadcast system of sowing accompanied with delayed sowing lack of technical know how, poor economic condition of farmers, heavy insect pest infestation etc. Due to more number of ploughing for field preparation the gap between harvesting of rice and sowing of rabi crops increased which enhance the soil moisture loss which is accelerated due to high temperature during sowing time of rabi crops. The broadcast method of sowing generally result in poor establishment due to uneven distribution and placement of seeds in moisture zone. Therefore an experiment was laid out to study the impact of ploughing intensity on establishment, productivity and moisture use efficiency of gram in rainfed rice based cropping system under National Agricultural Technology Project.

MATERIALS AND METHODS

An experiment was conducted on midland rainfed rice based cropping system during rabi seasons 1999-2001 at farmer field of village

Khatti, district Mahasamund, Indira Gandhi Agricultural University, Raipur. The soil was silty clay in texture, slightly acidic in reaction, normal in electrical conductivity (163 mS/m), medium in organic (Carbon 0.70%), low in available Nitrogen (231.3 kg N/ha), medium in available Phosphorus (11.9 kg P/ha) and high in available Potassium (306.2 kg K/ha). During kharif season, 604.2 mm and 506.2 mm rainfall was received during the year 1999-00 and 2000-01, respectively. The amount of rainfall received during rabi crop season was very low during both the year (15.5 mm during 1999-00 and 13.3 mm during 2000-01). The experiment was laid out in randomized block design with six replication with four treatments in each year. During the year 1999-00, P1, P3, P5 and P6 were included whereas during the year 2000-01 P1, P2, P4, P6 were included. The treatments were : P1 - direct seeding (Zero tillage), P2-one ploughing and seeding on same day, P3 - two ploughings and seeding on same day, P4 - two ploughings in different days and seeding, P5 - three ploughings in different days and seeding and P6 - farmers practices. Farmers practice comprised two ploughings of field and broadcasting and mixing by deshi plough. Gram variety JG-74 was tested in the experiment. Recommended dose of nutrient (20 kg N : 50 kg

Table 1. Plant population of gram as influenced by methods of cultivation and seeding at 20 DAS

Treatments	Plant population, number per m ²		
	1999-00	2000-01	Average
P1 - Direct seeding	18.0	19.9	18.9
P2 - One ploughing and seeding on same day	-	33.3	33.3
P3 - Two ploughing and seeding on same day	37.2	-	37.2
P4 - Two ploughings in different days and seeding	-	26.2	26.2
P5 - Three ploughing in different days and seeding	35.7	-	35.7
P6 - Farmers practice	26.5	22.3	24.4

Table 2. Yield and water use efficiency of gram as influenced by methods of cultivation and seeding

Treatments	Grain yield, q/ha		Straw yield, q/ha		Consumptive use, cm		Water use efficiency, kg/ha/cm	
	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01
P1 - Direct seeding	5.35	3.06	12.65	8.80	18.22	20.15	29.36	15.18
P2 - One ploughing and seeding on same day		5.16		13.44		20.21		25.53
P3 - Two ploughing and seeding on same day	8.95	-	20.59	-	17.62	-	50.79	-
P4 - Two ploughings in different days and seeding		4.26		11.82		20.95		20.33
P5 - Three ploughing in different days and seeding	6.60	-	16.42	-	21.09	-	31.29	-
P6 - Farmers practice	6.84	3.15	15.66	11.94	20.03	21.39	34.14	14.72
C.D. (P=0.05)	1.37	1.23	3.03	2.46	-	-	-	-

P₂O₅) was applied in all the treatments. Row to row spacing was 30 cm in line sown treatments. The crop was sown on 29 November 1999 and 17 November 2000 in the respective years.

RESULTS AND DISCUSSION

Plant Population

It was observed when ploughing of field and seeding of gram were done on the same day, the germination of the crop was more. It may be due to the placement of seeds in moist soil zone. Further increase in time interval between ploughing of field and sowing of crop has less plant population. It may be due to loss of soil moisture during field preparation and sowing. It was also observed that line sowing of gram gave the more establishment of plants than broadcast system. It is in Direct sowing of seeds

exhibited the lowest plant population than conventional ploughing.

Yield

The seed yield of gram was affected by soil moisture stress. Once or twice ploughing of field and seeding of gram on same day exhibited significantly higher yield than other treatments. However, it was at par with tow ploughings in different days and seeding during the year 2000-01. Further, the line sowing of gram produced higher seed yield than broadcasting system. It is in conformity with Samra and Dhillon (2000). The direct drilling of gram gave the least yield. It may be due to less plant population and growth of crop under no tillage condition. Similar findings were also reported by Pandey *et al.* (2000), Samra and Dhillon (2000) and Tripathi and Chauhan (2001).

Water use efficiency

Gram crop utilized 17.62 to 21.09 cm water during the year 1999-00 whereas it was 20.15 to 21.39 cm during 2000-01. The water use efficiency was higher when ploughing of field and seeding of crop were accomplished on the same day. The

increase in number of ploughing decreased the water use efficiency. Direct drilling exhibited low water use efficiency than that of conventional tillage. The water use efficiency was less during the year 2000-01 due to less productivity of the crop.

REFERENCES

- Pandey, A.K., Prakash, V., Singh, R.D. and Mani, V.P. 2000. *Ann. Agric. Res.*, 21 (4) : 548-551.
- Samra, J.S. and Dhillon, S.S. 2000. *Indian J. Agron.*, 45 (1) : 21-24.
- Tripathi, S.C. and Chauhan D.S. 2001. *Indian J. Agron.*, 46 (1) : 107-11

STUDIES ON SOIL MICROBIAL BIOMASS P, LABILE P AND PHOSPHATASE ACTIVITY UNDER CONTINUOUS INTENSIVE CULTIVATION IN AN INCEPTISOL

P. SANTHY, K. VIJILA, D. SELVI AND M. DHAKSHINAMOORTHY

*Department of Soil Science and Agricultural Chemistry
Tamil Nadu Agricultural University, Coimbatore - 641 003*

ABSTRACT

An exploration was made in the Long Term Fertilizer Experiment (LTFE), progressing in Tamil Nadu Agricultural University, Coimbatore since, 1972 in a medium black soil to quantify the amount of soil microbial biomass P, labile P, organic P and phosphatase activity under different nutrient input systems. The amount of microbial biomass P was found to be the highest for the combined application of 100% NPK + FYM and declined with increased rates of fertilizer application. The labile P, phosphatase activity and total P were found to be higher for integrated application of 100% NPK + FYM. There was a build up in soil total P levels compared to the level at the inception of the experiment in 1972, irrespective of treatments, except control (T10) and 100% N alone treatment (T7). Correlation studied emphasised the role of inorganic P in contributing to crop yield rather than organic P and the regression equation were drawn for explaining the interrelationship among the various parameters quantified.

Key words : Soil microbial biomass P, labile P, phosphatase activity and intensive cultivation.

Phosphorus is ultimately made available to plants through the weathering of minerals. During the time span of growing season, organic matter is the major contributor to the inorganic phosphorus pool in the soil, from which roots take up phosphorus. Decomposition by microorganisms is the dominating process for P release from organic matter. Additionally, P is also actively released from organic matter through biochemical mineralization (McGill and Cle, 1981), when roots and microorganisms selectively release P from the organic matter through the production of ester hydrolyzing enzymes, often called often called phosphatases. The induced phosphatase hydrolyze the ester bonds binding P to C in organic matter. During the process P is released without a concomitant release of C. Phosphatases are produced when P is the most growth limiting element (Spiers and McGill, 1978). Thus, an increase in levels of phosphatase should reflect an increased need of P. Acid phosphatase dominate in soils with a low pH, whereas alkaline phosphatases are dominant in soils with a higher pH, e.g., arable soils (Juma and Tabatabai, 1988).

The labile P fraction is considered to be readily plant available (Hedley et al. (1982). It may include inorganic P and easily available organic P in nucleic acids, phospholipids, and other P esters (Bowman and Cole, 1978), all of which are building blocks of living cells. In a study of eucalyptus forests, Adams et al. (1989) found that concentrations of labile P and microbial P were correlated with the productivity of the respective sites. A highly fertile soil is characterized by a higher content of these organic P fractions. He and Li (1987), after verifying the reliability of Bowman - Cole methods for organic P fractionation in relation to its availability of plants, showed that labile organic P was statistically related to RNA, lecithin, G-6-P, and glycerophosphate and could be extracted almost completely by 0.5 M NaHCO₃. This organic P fraction is easily available to plants (Mo et al., 1991).

MATERIALS AND METHODS

The experiment soil is medium black (Vertic Ustropept) with initial Olsen-P level of 4.9 mg kg⁻¹ and total P content of 490 mg kg⁻¹ at 0-15

cm depth Annually three irrigated crops are being raised, viz. finger millet (*Eleusine coracana* Gaertn.) during June to September, maize (*Zea mays*) from October to January and cowpea (fodder) (*Vigna unguiculata*) during March to April in a fixed rotation. There are ten treatments each replicated four times in a net plot size of 200 m².

The treatments are control (unfertilized), 100% optimal N alone, 100% optimal NP, 50% optimal NPK, 100% optimal NPK, 150% optimal NPK, 100% NPK + ZnSO₄, 100% NPK + FYM (farm yard manure), 100% NPK with HW (Hand weeding) and 10% optimal NPK (S free source). The optimal accounts of N, P₂O₅ and K₂O (100% NPK) are 90:45:17.5, 135:67:5:35 and 25:50:0 kg ha⁻¹, respectively, are used in all the treatments are sources of N, P and K except in 100% NPK (S free treatment where diammonium phosphate, urea and muriate of potash are the nutrient sources). ZnSO₄ is applied @ 25 kg ha⁻¹ only to maize and FYM @ 10 tons ha⁻¹ only to the finger millet. In 100% NPK with HW treatment, weeding is done by hand whereas in other plots chemical weed control is followed. The investigation was carried out from 65th crop of the experiment to 68th crop.

The biomass P content in soil was assessed as the difference between the unfumigated soil P divided by a K_p value of 0.40 by Fumigation-Incubation methods (Brookes et al., 1982). The inorganic P content in soil was estimated by Olsen et al., 1984. Labile P was extracted with 0.5M NaHCO₃ (pH 8.5) with organic P determined by the increase in the inorganic P after perchloric acid digestion. (Bowman and Cole, 1978). Enzyme phosphatase activity was determined as per Tabatabai and Bremner, 1969. The organic p was calculated as the difference between the total P and inorganic P.

RESULTS AND DISCUSSION

Biomass P

The maximum biomass P values (Table 1) were observed in NPK + FYM plots in all the three crops of the study. There was a declining trend for biomass P with higher doses of NPK application from 50% NPK to 150% NPK. When

P was withheld (100% N treatment and control), the microbial biomass P was found to be higher. A large decrease in microbial P was reported for the repeated additions of P + K + micronutrients by Clarhorms, (1993).

The inorganic P content decreased from 10.03 ppm (100% NPK + FYM) to 1.05 ppm in control and 1.31 ppm in 100% N alone treated plots. Similar trends could be seen in the pot harvest soils of succeeding crops of the experiment. These results again confirm the depletion (Jayasree et al., 2000) of P under conditions of non-application and an enhanced P status for the combined application of 100% NPK + FYM.

Labile P

The labile P fraction (Table 1) is considered to be readily plant available (Hedley et al., 1982). It may include inorganic P and easily available organic P in nucleic acids, phospholipids and other P esters (Bowman and Cole, 1978), all of which are building blocks of living cells. The content of labile P is an useful index of whether the soil is rich in P and organic matter. In the present investigation, the soil labile P was assessed in the soils after 65, 67 and 69th crops of LTFE. The labile P was highest in 150% NPK (18.2 ppm) and lowest in 100% N (2.24 ppm) alone. Rest of the treatments were on par with each other except control and 100% NPK + FYM. In the soils of 67 and 69th crops, highest labile P contents were recorded for the integrated application of 100% NPK + FYM. There was a gradual increase in labile P content from 50% NPK to 150% NPK application.

Phosphatase activity

The phosphate activity in the experimental soil ranged from 26 to 18.4 µg of pnp g⁻¹ soil hr⁻¹ (Table 2). The maximum phosphate activity was recorded for the combined application of 100% NPK + FYM treatment. Acid phosphatase are not primarily associated with the release of P from organic matter, but they act mainly as catalysts of reactions related to internal cell metabolism and energy transformation inside cells (Burns, 1982), upon cell death, internally produced phosphatases are released to the soil solution, where they are quite long lived. Soil phosphatase enters the soil (1) as enzyme released from living

Table 1. Biomass P and labile P in crops

Treatments	Biomass P ($\mu\text{g/g}$ soil)			Mean	Labile P (ppm)			Mean
	65	67	69		65	67	69	
50% NPK	15.2	16.4	16.8	16.13	11.78	12.14	13.45	12.46
100% NPK	13.2	13.9	13.2	13.43	16.10	15.20	17.26	16.49
150% NPK	7.4	8.6	7.8	7.93	18.20	17.56	18.24	18.00
100% NPK+HW	11.8	12.5	13.2	12.50	13.46	14.25	16.54	14.75
100% NPK+MN	12.6	10.9	12.8	12.10	15.84	15.45	15.52	15.60
100% NP	12.1	12.0	12.5	12.20	12.18	13.15	13.45	12.93
100% N	8.2	7.6	7.5	7.76	2.24	3.45	3.8	3.16
100% NPK+FYM	14.4	15.8	17.2	15.80	17.82	18.52	19.76	18.70
100% NPK(-S)	12.3	13.1	14.8	13.40	11.76	12.26	2.48	12.16
CONTROL	8.3	7.9	6.2	7.46	2.80	2.56	3.52	2.96
C.D. at 5%	2.4	1.8	1.4	-	8.0	2.4	2.65	-

cells to improve P availability and (2) as originally intercellular enzyme released to the soil solution from cells that are ruptured by grazing of the microbial predators, adverse conditions etc. (Clarholms, 1993). The higher activity of the enzyme phosphatase in the organics and inorganics treatment may have reflected a higher biological activity, which led to improved growth and yield of crops. Harrison (1982) ascribed increased levels of acid phosphatases to elevated levels of microbial activity, including decomposition of organic matter. Decomposition provides C for microbial growth as well as inorganic P for plant uptake. Phosphate is released secondarily through microbial cell death.

The correlation studies (Tables 3 & 4) revealed a significant positive relationship between phosphatase activity and biomass P. Bottom *et al.* 1985, found a strong correlation between acid phosphatase activity and microbial biomass in soil fertilized both with readily available P and with organic fertilizers, a result that emphasizes the contribution from rupture of microbial cell.

Organic P

Both organic and inorganic P are easily absorbed, thus becoming less available to plants. However, labile organic P can be used by plants (He and Li, 1987; Mo *et al.*, 1991), and the nutritional effects of the labile organic P fractions are superior to those of inorganic P at the same concentration (Sun and Zhang, 1992), caused by

the low mobility of inorganic P in soil. In the present study, among the three crops under investigation, the mean organic P content were higher for 100% NPK + FYM in two crops (Table 2). There was a gradual decline in the P content from 150% NPK application to 50% NPK application.

When inorganic P is supplied together with organic manure, the formation of organic P is promoted. Further, the application of inorganic P fertilizer combined with organic manure should be regarded as an effective way of the plant availability of inorganic P in soils. Therefore, it is suggested that the application of inorganic P fertilizer combined with organic manures may be an effective way of protecting inorganic P against intensive sorption in soils.

Total P

The highest total P content was recorded under 150 per cent NPK (Table 2). This was followed by 100 per cent NPK + FYM content. The least total P was recorded under N alone which was comparable with that of control. An increase in the quantum of applied P had resulted in an appreciable build up in total P content. In general, there was an increase in the total P content in all the treatments excepting N alone and control.

The results of the experiment indicated that a higher microbial biomass P, labile P, maximum activity of enzyme phosphatase, the build up in

soil total P could be achieved for the application of 100% NPK + FYM @ 10 tons ha⁻¹. Correlation studies (Table 3) emphasized the role of

inorganic P in contributing to crop yield rather than organic P. The inorganic P was positively and significantly correlated to biomass P (Table 4).

Table 2. Phosphatase activity, organic P and total P in crops

Treatments	Phosphatase activity (μ g of pnp in soil/hour)			Mean	Organic P (ppm)			Mean	Total P (ppm)			Mean
	65	67	69		65	67	69		65	67	69	
50% NPK	23.3	23.9	23.7	23.6	655	681	694	677	661	696	712	690
100% NPK	24.8	25.1	24.5	24.8	795	799	845	813	800	815	892	836
150% NPK	25.3	25.8	26.2	25.8	986	980	1010	992	992	995	1010	999
100% NPK+HW	23.4	23.8	22.2	23.2	858	678	720	752	780	695	856	777
100% NPK+MN	24.5	22.9	22.3	23.2	820	613	620	684	825	875	650	783
100% NP	21.3	20.9	20.9	21.0	806	804	810	807	810	820	875	835
100% N	20.3	17.5	18.4	18.7	319	345	420	361	320	350	280	317
100% NPK+FYM	26.0	25.6	25.8	25.8	895	988	1020	968	900	1010	1015	975
100% NPK(-S)	22.3	22.6	23.4	22.8	816	813	820	816	820	830	845	832
CONTROL	18.4	16.9	17.0	17.4	397	396	400	398	398	400	390	396
C.D. at 5%	3.64	3.27	3.41	-	126	134	217	-	208	135	52.9	-

Table 3. Correlation Matrices of yield and different forms of P

Parameters	Phos. Activity	Organic P	Inorganic P	Labile P	Biomass P	Total P
Crop yield (65)	0.338*	0.428**	0.596**	0.490**	0.347**	0.484**
Crop yield (67)	0.696**	0.824**	0.868**	0.866**	0.418**	0.827**
Crop yield (69)	0.568**	0.630**	0.655**	0.602**	0.445**	0.645**

Table 4. Correlation matrices between different forms of P

Parameter	Organic P			Inorganic P			Phosphatase activity		
	65	67	69	65	67	69	65	67	69
Biomass P(65)	0.355**	-	-	0.503**	-	-	NS	-	-
Biomass P (67)	-	0.470**	-	-	0.621**	-	-	0.549**	-
Biomass P (69)	-	-	NS	-	-	0.507**	-	-	0.509**

REFERENCES

- Adams, M.A., Attiwill, P.M., and Polglase, P.I. 1989. *Biol. Fertility of Soils*, **8** : 212.
- Bolton, H.Jr., Elliott, L.F., Papendick, R.I. and Bendicek, D.F. 1985. *Soil Biol. Biochem.*, **17** : 297.
- Bowmen, R.A., and Cole, C.V. 1978. *Soil Sci.*, **125** : 95.
- Brookes, P.C., Powlson, D.S., and Jenkinson, D.C. 1982. *Soil Biol. Biochem.*, **14** : 319.
- Burns, R.G. 1982. *Soil Biol. Biochem.*, **14** : 423.
- Clarholms, M. 1993. *Biol. Fertility of Soils*, **16** : 287.
- Harrison, A.F. 1982. *Soil Biol. Biochem.*, **14** : 343.
- He, T., and Li, S.J. 1987. *Acta Pedol Sinica*, **24** : 152.
- Hedley, M.J., Stewart, J.W.B., and Chauhan, B.S. 1982. *Soil Sci. Soc. Am. J.*, **46** : 970.

- Juma, N.G., and Tabatabai, M. 1988. *Soil Biol. Biochem.*, 20 : 533.
- Mc. Gill, W.B., and Cole, C.V. 1981. *Geoderma*, 26 : 267.
- Mo, S.X., Qian, C.J. 1991. *Acta Pedol Sinica*, 28 : 309.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. 1954. *USDA Cir.* 939.
- Spiers, G.A., and McGill, W.B. 1978. *Soil Biol. Biochem.*, 11:3.
- Sun., X., and Zhang, Y.S. 1992. *Acta Pedol Sinica*, 29 : 365. *Soil Biol. Biochem.* 14 : 423.23.
- Tabatabai, M.A., and Bremner, J.M. 1969. *Soil Biol. Biochem.* 1 : 301.

ESTIMATION OF VARIABILITY PARAMETERS FOR SOME QUANTITATIVE CHARACTERS IN SESAME (*SESAMUM INDICUM*)

S.B. SINGH AND S.D. SINGH

Research Station
Sardar Vallabh Bhai Patel University of Agriculture and Technology
Ujhani-243639

ABSTRACT

Thirty advance lines and ten varieties of sesamum were studied during Kharif 1996, 1997 and 1998. Wide range of variation were recorded for all the characters, except capsule length under study. High heritability alongwith high magnitude of genetic advance in percentage of mean was recorded for capsules/plant and grain yield. Days to maturity exhibited high heritability and low genetic advance. Phenotypic coefficient of variation were higher than the genotypic coefficient of variation for all the characters under study.

Key words : Genetic variability, sesame, association, heritability.

The success of any breeding programme depends on the account of the variability present for different characters in a population and its efficient management and utilization. In order to exploit different type of gene action in the population, information on the relative magnitude of genetic variability in the population, heritability and genetic advance of important agronomic traits is essential, heritability with genetic advance is of more value in predicting the effect of selection. If the heritability is mainly due to additive gene effects, the realized genetic gain would be high in comparison to the situation where, both additive and non-additive gene effects are involved.

Sesame is an important rainy season kharif oil seed crop. Hence, an effort was made to investigate the extent of genetic variability and selection parameters, viz. heritability broad sense and genetic advance for nine important characters of this crop.

MATERIALS AND METHODS

The experimental material consisted 30 advance lines and 10 varieties of sesamum viz; T-4, T-78, HT-37, Shekhar, G-1, T-13, T-12, LCT 97-1 PT-1 and local were grown in randomized block design with 3 replications during kharif 1996, 1997, and 1998 at S.V. Bhai Patel University

of Agriculture and Technology, Research station Ujhani (Budaun), Uttar Pradesh. Each genotypes consist 3 rows, each 5m long at 30 cm apart. Plant to plant distance was maintained at 10cm. Observations were recorded on 10 randomly selected plant for each genotype during all the three year for nine characters viz.; days to 50 per cent flowering, days to maturity, plant height (cm) no. of primary branches, capsule/plant, capsule length, capsule width (cm), seeds/capsule and grain yield (q/ha). Genotypic and phenotypic coefficient of variation were calculated according to the method suggested by Burton and Devane (1953). Heritability estimates were obtained following the method Hanson *et al.*, (1965). Heritability estimates were obtained following the method Hanson *et al.*, (1965). The genetic advance was calculated by the formula given by Johanson *et al.* (1955).

RESULTS AND DISCUSSION

The data on the values of different characters and analysis of variance of treatments showed significant differences among the genotype for all the 3 years. Wide range of variation were recorded for all the character, viz., days to 50 per cent flowering (42.25-50.25, 38.50-47.75 and 35.00-46.50), days to maturity (85.00-93.50, 82.00-96.50 and 79.00-89.00), plant

height (134.50-154.65, 129.62-148.92 and 138.37-147.95), no. of primary branches (3.00-5.25, 2.00-4.75 and 2.00-4.60), capsules/plant (52.12-69.25, 44.37-60.37 and 41.90-71.10), capsules width (2.78-3.27, 2.67-3.08 and 2.68-3.08), seeds/capsules (65.10-74.12, 61.37-68.75 and 62.80-69.60) and grain yield (3.85-4.00, 3.37-4.97 and 2.15-4.48) except capsule length during all the three years, respectively. Variability in quantitative characters of sesamum was also reported by Gupta and Chopra (1984). Plant height, capsules/plant, seeds/capsule and grain yield showing high range of variation indicated good scope for improvement.

Phenotypic coefficient of variation were higher than the genotypic coefficient of variation for all the characters during all the 3 years (Table 1). The phenotypic coefficient of variation was highest for primary branches per plant (20.96, 23.73 and 22.58) followed by grain yield 16.60, 21.79 and 18.61) and capsules/plant (12.24, 20.76 and 16.82) and was lowest for days to maturity (2.84, 4.38 and 1.72) during all the 3 years respectively. Highest coefficient of variation was observed (Table 1) for grain yield (16.35, 20.89 and 11.87) followed by primary branches (15.14, 19.42 and 14.23) and capsules/plant (10.83, 20.08 and 11.13). Similar results were also reported by Singh *et al.* (1997) in sesamum.

The high magnitude of genotypic coefficient of variation further revealed great extent of variability present in these characters, thereby suggesting good scope for improvement create variability either by hybridization or mutation followed by selection.

The high values of heritability was observed for days to maturity, plant height, capsules/plant and grain yield. Days to 50 per cent flowering, primary branches per plant, capsule length, capsule width and seeds/capsule showed moderate to low value of heritability (below 80%). However, the highest heritability was recorded for capsules/plant and lowest for primary branches/plant. Character showing high heritability values indicated that such characters have more number of additive factors Panse (1957).

Table 1. Mean phenotypic, genotypic coefficient of variation, heritability and genetic advance for nine characters in sesame

Character	Phenotypic coefficient of variation			Genotypic coefficient of variation			Heritability %			Genetic advance as percentage of mean		
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998
Days to 50% flowering	5.18	8.59	5.62	4.59	8.50	5.21	78.36	70.27	76.20	8.36	16.63	9.10
Days to maturity	2.84	4.38	1.72	2.72	4.22	1.11	91.97	92.83	91.85	5.37	8.37	5.57
Plant height (cm)	5.45	4.74	8.06	5.16	4.48	5.09	89.64	89.46	89.90	10.07	8.74	6.62
Primary branches/plant	20.96	23.73	22.58	15.14	19.42	14.23	62.17	66.97	69.75	32.65	32.67	38.65
Capsules/plant	12.24	20.76	16.82	10.83	20.08	11.13	92.29	93.52	93.78	39.72	40.00	35.16
Capsule length (cm)	4.36	4.08	2.51	3.87	0.80	1.96	78.65	68.57	61.26	7.06	3.20	3.21
Capsule width (cm)	6.40	5.06	5.56	5.57	4.18	4.93	75.69	78.76	78.76	10.00	7.27	8.99
Seeds/capsule	5.63	4.91	4.73	5.19	3.37	4.10	74.95	77.10	75.05	9.84	4.77	7.32
Grain yield (q/ha)	16.60	21.79	18.61	16.35	20.89	11.87	97.14	91.86	92.36	33.22	41.18	35.60

The expected genetic advance expressed as per cent of mean ranged from 5.37, 8.37 and 1.47 (days to maturity) to 39.78, 40.00 and 35.16 (capsules/plant) during all the 3 years, respectively. High genetic advance above 30% were recorded for primary branches/plant, capsules/plant and grain yield. Remaining all characters expressed low genetic advance.

Heritability is a measure of genetic relationship between parents and progeny and had offspring. High heritability alone is not enough to make efficient selection unless the information is accompanied for substantial amount of genetic advance. Thus genetic advance is yet another important selection parameter. Johanson *et al.* (1955) pointed out that without genetic advance the estimate of heritability would not be practical importance in selection based on phenotypic appearance. They further emphasized that the genetic gain should be considered along with heritability in streamlining coherent selection breeding programme.

In the present study high heritability coupled with high genetic advance in percentage of mean was recorded for capsules/plant and grain yield, indicated the major role of additive gene action in inheritance of these characters. High to medium heritability and low to high genetic advance recorded for days to 50% flowering, days to maturity, plant height, primary branches/plant, capsule length, capsule width and seeds/capsule revealed the major role of non additive gene action in the transmission of these characters from parents to off-spring. Panse (1957) viewed that if a character governed by non-additive gene action, it may give high heritability and low genetic advance, whereas if it is governed by additive gene action, heritability and genetic advance both would be high. High estimates of heritability alongwith high genetic advance provides good scope for further improvement in advance gene actions if these characters subjected to mass progeny or family selection.

REFERENCES

- Burton, G.W. and De Vane E.H. 1953. Estimating heritability in fescue clonal material. *Indian Journal of Agronomy*, **45** : 478-481.
- Gupta, B.S. and Chopra, D.P. 1984. Genetic variability, correlation and path coefficient analysis in sesamum. *Indian Journal of Agricultural Science*, **54** (8) : 1030-33.
- Hanson, C.H., Robinson H.F. and Comstock R.E. 1956. Biometrical studies of yield in segregating population of Korean lespepeza. *Indian Journal of Agronomy*, **48** : 268-272.
- Johanson, C.H. Robinson H.F. and Comstock, R.E. 1955. Estimating the genetic and environmental variation in soybean. *Indian Journal of Agronomy*, **47** : 314-18.
- Panse, V.G. 1957. Genetics of Quantitative characters in relation to plant breeding. *Indian Journal of Genetics and Plant Breeding*, **17** : 318-28.
- Singh, P.K., Dixit R.K. and Yadav, R.K. 1997. Estimation of genetic parameters, characters estimation and path analysis in seasame. *Crop Research*, **13**(1) : 115-19.

EARLINESS, YIELD AND YIELD ATTRIBUTES IN SEVEN IDENTIFIED FUSARIUM WILT RESISTANT GENOTYPES OF MUSKMELON, CUCUMIS MELO L.

JAAGRATI JAIN

*Division of Genetics
Indian Agricultural Research Institute, New Delhi-110 012*

ABSTRACT

Present attempt has been made towards characterisation of seven identified Fusarium wilt resistant (FWR) genotypes of muskmelon for earliness, yield, yield attributes and biochemical constituents. WMR-29, known for powdery mildew resistance (Pm-w) and identified earlier as FWR genotype based on artificial screening, with estimated yield of 19.26 t/ha, has been identified for improvement of disease resistance and maintaining better yield traits in existing cultivated varieties (cvs.).

Key words : Muskmelon, FWR genotypes, earliness, yield, yield attributes, biochemical constituents.

Collection and assessment of genotypes with genetic diversity for different traits including earliness, better fruit quality, multiple disease resistance, yield and its different components with market acceptability is a step towards identification followed by utilization of genetically diverse genotypes to develop promising varieties/lines. This will help in economizing and popularizing muskmelon production through incorporation of seven identified Fusarium wilt resistant genotypes (Jain and Sharma, 2001) of Cucumis melo for desirable traits like multiple disease resistance, biochemical traits, earliness, better fruit quality, yield attributes like fruit weight, total yield/plant, number of fruits/plant, high T.S.S. with market acceptability for fruit size, shape, colour, flesh thickness, flesh color and improved estimated yield (tonnes/ha).

MATERIALS AND METHODS

Performance of seven identified Fusarium wilt resistant lines and four cvs. of melon, cucumis melo L. for earliness, fruit maturity, yield and quality was tested in field for two years (1999-2000) from January to June/July. Crop was nursery raised on 0.1% captaf drenched soil mixture (soil : FYM : sand in 1:1:1 ratio) under polyhouse conditions in polythene bags. Field was prepared with 30 tonnes/ha of FYM.

Standardized agronomy practices were followed to obtain yield of crop. Furrows/channels 60 cm wide and spaced 2.5 to 3 meters were prepared using tractor driven disc. Baselin (3.3 kg/ha) weedicide was applied along with irrigation water in channels before transplanting to control weeds. Thereafter, basal dressing was done with 200 kg/ha urea, 300 kg/ha superphosphate and 100kg/ha potassium sulphate or muriate of potash. Distance between two hills was kept at 60 cm to 75 cm. Soil of hills was treated with 1/3 TSF (Teaspoon full) captaf + 1/3 TSF Furadan before transplanting to check initial diseases and pests. Urea was sprinkled around root zone (wet) of plants during early part of growing season. Mixture of 0.2% sevin and 1% rogor in water was sprayed during vegetative growth to control red pumpkin beetles and jassids. Irrigation was provided every fifth day upto fruit maturity, thereafter only when it was needed. Site data including days to fruit maturity, days from transplanting to first picking, data on yield attributes such as fruit weight, number of fruits/plant, number of plants/hill, total yield/plant (kg) and estimated yield (tonnes/ha) was recorded. An account of biotic stress susceptibility to field diseases like Fusarium wilt, CGMMV and mildews was maintained and biochemical traits (TSS and ascorbic acid content mg/100 mg) were estimated using hand

refractometer and 2, 6 - dichlorophenol indophenol visual titration method (Ranganna, 1999).

RESULTS AND DISCUSSION

Seven identified *Fusarium* wilt resistant genotypes of muskmelon were further characterized for earliness (days from transplanting to first picking), fruit maturity, yield and yield components (Table 1) and compared with cv. Pusa Madhuras (PM). Estimated yield of WMR-29 was found to be 19.26 t/ha comparable with 19.98 t/ha in cv PM. Fruits of WMR-29 were medium sized, round, ribbed with orange flesh (Jain and Verma, 2000). Average fruit weight was 628.12 ± 4.41 gms with total yield of plant as 1.02 kg. Fruits matured in 31.91 ± 3.41 days. Fruit were borne 1.62 fruits/plant on an average. Maximum fruit setting was found to be 38.08 ± 7.12 percent in WMR-29. It takes 108.70 ± 25.74 days from transplanting to first picking. T.S.S. was found to be low (6.09 ± 1.19) and ascorbic acid content was > 20 mg/100 mg of sample (Table 2). Estimated yield in six other identified *Fusarium* wilt resistant genotypes varied from 7.42 to 14.85 t/ha. Fruits matured in 30.58 ± 1.52 to 36.71 ± 2.98 days. Average fruit weight was in between 457.5 ± 152.02 gms and 755.20 ± 19.15 gms. Total yield/plant was 0.41 kg to 1.23 kg with fruiting potential of 0.9 to 1.63 fruits/plant. Earliness in six *Fusarium* wilt resistant genotypes was 103.76 ± 29.79 to 123.88 ± 17.74 days from transplanting to first picking, indicating a difference of 20.12 days. Estimated yield was lowest in Top-mark Bush (known for compact plant habit and identified as *Fusarium* wilt resistant genotype) with total yield/plant as 0.41 kg and number of fruits/plant as 0.90 (Table 1). An account of biochemical constituents (TSS and ascorbic acid content (mg/100 mg) for seven genotypes can be obtained from Table 2. WMR-29, known for powdery mildew resistance (Pm-w) (Jain and Verma, 2000), identified earlier for field resistance to major virus and fungal diseases and confirmed as *Fusarium* wilt resistant genotype based on artificial screening (Jain and Sharma, 2001) can be utilized as *Fusarium* wilt resistant introduction followed by selection and can also

Table 1. Performance of cv and *Fusarium* wilt resistant (FWR) genotypes for earliness, yield and yield components

CV/FWR genotypes	Days to fruit maturity	Earliness	Yield and yield components				
			Average fruit weight (gm)	No. of fruits/plant ($\bar{x}$)	No. of plants/hill ($\bar{x}$)	Total yield/plant (kg)	Estimated yield (t/ha)
	$\bar{x} \pm S.D.$	$(\bar{x} \pm S.D.)$	$(\bar{x} \pm S.D.)$				
cv. Pusa Madhuras	32.51±4.98	108.4±25.92	664.48±141.16	1.52	1.98	1.01	19.98
FWR genotypes :							
Honey-dew	32.43±1.25	103.76±29.79	674.99±134.34	1.3	1.77	0.84	14.85
MR-1	34.94±1.32	117.21±25.75	545.13±124.72	1.35	1.64	0.74	12.02
Nantais-oblong	30.58±1.52	123.88±17.74	755.20±19.15	1.63	1.09	1.23	13.36
PT 414723	36.01±1.43	111.73±25.54	718.74±114.36	1.03	1.38	0.74	10.18
PPMR-5	36.71±2.98	125.17±20.58	677.50±420.72	1.27	1.65	0.86	14.14
Top-Mark Bush	31.57±6.46	107.85±35.15	457.5±152.02	0.90	1.81	0.41	7.42
WMR-29	31.91±3.41	108.70±25.74	628.12±4.41	1.62	1.90	1.02	19.26

* Mean $\pm$ S.D.

Table 2. Biochemical constituents of cv Pusa Madhuras and seven FWR genotypes

CV/FWR genotypes	Total soluble solids (TSS) ($\bar{x} \pm S.D.$)	Ascorbic acid content (mg/100 gm) ($\bar{x} \pm S.D.$)
cv. Pusa Madhuras	7.41 $\pm$ 2.24	*18.6 $\pm$ 7.06
FWR genotypes :		
Honey-dew	6.90 $\pm$ 1.70	*20.38 $\pm$ 4.18
MR-1	5.89 $\pm$ 1.25	11.27 $\pm$ 6.05
Nantais-oblong	4.33 $\pm$ 0.46	9.51 $\pm$ 5.04
P1 414723	5.41 $\pm$ 0.29	*13.09 $\pm$ 11.51
PMR-5	6.37 $\pm$ 0.88	3.97 $\pm$ 1.01
Top-Mark Bush	5.43 $\pm$ 1.32	10.34 $\pm$ 2.05
WMR-29	6.09 $\pm$ 1.19	*14.51 $\pm$ 12.62

*Ascorbic acid content (Mean $\pm$ SD) > 20 mg/100 gm of sample

be incorporated in muskmelon improvement/variety development programme following hybridization with existing cvs. WMR-29 has earlier contributed in development of cv Punjab Rasila resulting from a cross between WMR 29 X Hara Madhu (Nandpuri, *et al.* 1995).

CV Pusa Madhuras and other existing cvs (Pusa sharbati, Hara Madhu, Durgapur Madhu) characterised earlier for earliness, yield and

quality characters (More and Sheshadhari 1980. a; Saimbhi and Nandpuri, 1980), provide a good varietal diversity (More and Sheshadhri, 1980 b) with good market acceptability. Attempts are required to be made towards incorporation of Fusarium wilt resistance and Pm-w from WMR-29 maintaining better yield traits. Identification, molecular mapping and cloning of genes known for disease resistance is also required in WMR-29 and six other FWR genotypes, in future.

REFERENCES

- Jain, J. and Sharma, P. 2001. *Cucurbit Genetics Cooperative*. 24 : 26-28.
- Jain, J. and Verma, V.K. 2000. *Cucurbit Genetics Cooperative*, 23 : 37-40.
- More, T.A. and Sheshadhri, V.S. 1980a. *Vegetable Sci.* 7(1) : 27-40.
- More, T.A. and Sheshadhri, V.S. 1980b. *Vegetable Sci.* 7(2) : 108-117.
- Nandpuri, K.S., Lal, Tarsem and Dhiman, J.S. 1995. *Indian Hort.* 40(3) : 4, 9.
- Ranganna, S. 1999. Vitamins, In : Handbook of analysis and quality control for fruit and vegetable products, 2nd edition. Tata Mc. Graw Hill Publishing Company Ltd. New Delhi pp. 105-106.
- Saimbhi, M.S. and Nandpuri, K.S. 1980. *Vegetable Sci.* 7(1) : 41-47.

CORRELATION AND PATH ANALYSIS IN A DIALLEL CROSS OF INDIAN BEAN

A.B. BAGADE, D.U. PATEL, S.C. MALI, R.M. KSHIRSAGAR AND P.B. PATEL

*Regional Sugarcane Research Station
Gujarat Agricultural University, Navsari-396 450 (Gujarat)*

ABSTRACT

Correlation among the parents and F_1 s of 10×10 diallel crosses and the path coefficient analysis were studied in case of Indian bean. The seed yield per plant was positively and significantly associated with pods per plant and negatively correlated with plant height. Pods per plant had the highest direct effect followed by 100-seed weight on seed yield. The selection criteria based on pods per plant will give good results for yield improvement in Indian bean.

Key words : Correlation, path analysis, Indian bean.

A thorough understanding of the association of plant characters with yield and among themselves is essential for successful crop improvement programme. The inter-relationship among the yield components can be analysed with the help of path coefficient analysis which permits the separation of the correlation coefficient into direct and indirect effects. The present study in Indian bean is an attempt in this direction.

MATERIALS AND METHODS

The experiment material consisted of parents, F_1 s and a standard check of 10×10 diallel set of Indian bean excluding reciprocal was grown in a randomized block design with three replications at Pulse Research Station, N.M. College of Agriculture, Navsari (Gujarat) during rabi 2000-2001. The ten parents included were ND 4, ND 13, ND 16, ND 17, ND 20, NW 102, NW 104, NW 106, ND 10 and Wal-126-36. The row to row and plant to plant distance was 60 and 15 cm, respectively. Recommended cultural practices were adopted to grow a good crop. Randomly selected five plants in each genotype taken from each replication to record the observations. The data were recorded for number of days to 50 per cent flowering, plant height, number of branches per plant, number of pods per plant, pod length, number of seeds per pod, 100-seed weight, seed yield per plant, protein content and number of days to maturity.

Genotypic and phenotypic correlation coefficients were calculated using the procedure described by Panse and Sukhatme (1978). Path coefficient analysis based on genotypic correlation was performed according to Dew and Lu (1959).

RESULTS AND DISCUSSION

The results of phenotypic and genotypic correlations among ten characters were presented in (Table 1). It was observed that genotypic correlations were greater than the phenotypic correlation in almost all the cases indicating that the environmental influences were not marked enough to alter the degree of association amongst the characters studied. Seed yield per plant possessed highly significant positive correlations with number of pods per plant only. Number of days taken to mature recorded significant negative correlation with seed yield per plant. Whenever, there was increase in the number of pods per plant, it increased the seed yield per plant. The results obtained are in accordance with the finding reported by Pawar (1996) in Indian bean. The character days to 50 per cent flowering recorded significant negative genotypic days to 50 per cent flowering recorded significant negative genotypic correlation with seeds per pod and high significant negative correlation with protein content in the seed. Topare (1994) also found the same results in Indian bean. Plant height recorded significant negative genotypic

Table 1. Genotypic and phenotypic correlation coefficient of seed yield per plant with other characters

Characters	Days to 50% flowering	Days to maturity	Plant height	Pod length	Branches/ plant	Pods/ plant	Seeds/ pod	100-seed weight	Protein content	Seed yield/ plant
Days to 50% flowering	rg	0.338**	0.111	0.042	-0.028	-0.023	-0.240*	0.338**	0.415**	0.030
	rp	0.301**	0.100	0.034	-0.005	-0.023	-0.174	0.320**	0.392**	0.028
Days to maturity	rg		0.202	0.213	-0.240*	-0.153	0.305**	0.323**	0.036	-0.051
	rp		0.112	0.204	-0.222*	-0.133	-0.212	0.304**	0.037	-0.047
Plant height (cm)	rg			0.117	0.169	-0.284**	0.103	0.065	-0.002	-0.252*
	rp			0.163	0.152	-0.141	0.064	0.032	0.014	-0.187
Pod length	rg				-0.121	0.079	-0.070	0.124	0.217	0.072
	rp				-0.072	0.075	-0.041	0.119	0.203	0.070
Branches/plant	rg					0.056	0.192	-0.015	0.017	0.138
	rp					0.059	0.174	-0.020	0.018	0.102
Pods/plant	rg						0.021	-0.327**	-0.217	0.812**
	rp						0.018	-0.285**	-0.190	0.730**
Seeds/pod	rg							-0.244*	-0.089	-0.129
	rp							-0.160	-0.069	-0.123
100-seed weight	rg								0.007	0.062
	rp								0.000	0.058
Protein content	rg									-0.170
	rp									-0.167
Seed yield/plant	rg									
	rp									

*Significant at 5%. ** Significant at 1%.

Table 2. Direct and indirect effects of nine causal variables on grain yield in Indian bean

Characters	Direct effect	Days to 50% flowering	Days to maturity	Plant height	Pod length	Branches/plant	Pods/plant	Seeds/pod	100-seed weight	Protein content	Correlation coefficient
Days to 50% flowering	-0.112	-	0.002	-0.001	-0.001	-0.003	-0.021	0.027	0.130	0.009	0.030
Days to maturity	0.007	-0.038	-	-0.001	-0.007	-0.026	-0.142	0.034	0.124	-0.001	-0.051
Plant height (cm)	-0.005	-0.012	0.001	-	-0.004	0.018	-0.264	-0.012	0.025	0.000	-0.252*
Pod length	-0.035	-0.005	0.001	-0.001	-	-0.013	0.073	0.008	0.047	-0.005	0.072
Branches/plant	0.109	0.003	-0.002	-0.001	0.004	-	0.52	-0.021	-0.006	0.000	0.138
Pods/plant	0.928	0.003	-0.001	0.001	-0.003	0.006	-	-0.002	-0.125	0.005	0.812*
Seeds/pod	-0.112	0.027	-0.002	0.000	0.002	0.021	0.019	-	-0.084	0.002	-0.129
100-seed weight	0.383	-0.038	0.002	0.000	-0.004	-0.002	-0.304	0.025	-	0.000	0.062
Protein content	-0.022	0.046	0.000	0.000	-0.008	0.002	-0.201	0.010	0.003	-	-0.170

Residual effect = 0.194.

correlation with seed yield per plant. Negative correlation of plant height with seed yield per plant indicated that dwarf plant would increase the seed yield. Days to 50 per cent flowering showed highly significant positive correlation with days to maturity. This indicates that flowering time is an important indicator of maturity. The above results are in close agreement with Jindal and Gupta (1984) in cowpea.

Path coefficient analysis provides an aid for sorting out the total correlation into direct and indirect effects of different characters on yield. Pods per plant, 100-seed weight and branches per plant recorded the highest positive direct effect on seed yield per plant. Results reported earlier by Kabir and Sen (1989) in Indian bean support the present findings. The result revealed that pods per plant was found to have the greatest contribution towards the seed yield through its direct effect. Maximum positive direct effects were observed in case of branches per plant and 50 per cent flowering through pods per plant and 100-seed weight and plant height through pods per plant. The indirect effects in case of protein content, seeds per pod, pods per plant and pod length were negligible.

REFERENCES

- Dew, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.*, 51 : 515-518.
- Jindal, S.K. and Gupta, B.S. 1984. Components analysis of yield in cowpea. *Indian J. Agric. Sci.*, 54 (3) : 183-185.
- Kabir, J. and Sen, S. 1989. Correlation and path analysis in lablab niger medik, *Dolichos uniflorus* Lam and their F₁s. *Trop. Agric.*, 66 (3) : 281-283.
- Panse, V.G. and Sukhatme, P.V. 1978. "Statistical method for agricultural workers II ed." ICAR Publication, New Delhi.
- Pawar, R.M. 1996. Genetic variability, correlation, path and D² analysis in Indian bean. M.Sc. (Agri.) thesis (unpublished) submitted to GAU, SK Nagar.
- Topare, S.S. 1994. Genetic variability, correlation and path analysis in lablab bean. Unpublished thesis submitted to Konkan Krishi Vidyapith, Dapoli.

PERFORMANCE OF WHEAT VARIETIES UNDER FURROW IRRIGATED RAISED BED-PLANTING SYSTEM (FIRBS) IN SANDY LOAM SOIL OF NORTH BIHAR

ANIL KUMAR, S. CHOWDHURY, I.B. PANDEY* AND O.R. FARUQUI

IARI Regional Station, Pusa-848125 (Samastipur)

ABSTRACT

An experiment was conducted during rabi seasons of 1999-02 at IARI, Regional Station, Pusa (Samastipur) to study the economisation of inputs for sustainable higher yield of wheat through FIRB system. Grain yield of wheat varieties grown in FIRB system reduced with decrease in the tillering ability of varieties. Among the timely sown varieties, HD2733 recorded significantly higher number of tillers per square meter, thus highest grain yield. However, under late sown wheat varieties HP 1744 in first year and PBW 373 in second year showed its superiority over rest of wheat varieties and produced significantly higher tillers per square meter and grain yield. Normal yield of wheat varieties was achieved under FIRB system of wheat cultivation even after reducing the level of chemical fertilizer application and irrigation to 75 and 70 per cent of recommended dose respectively, as compared to flat bed system.

Key words : Wheat, FIRB, performance, north Bihar.

Intensive cultivation and increasing price of inputs necessitates maximum output per unit input for cost effective efficient production. The FIRB (Furrow Irrigated Raised Bed-planting) system of wheat cultivation has been found to have distinct advantages with respect to saving in terms of irrigation water, seed, fertilizer and easier weed management over conventional flat bed system. It also helps wheat crop to utilize solar radiation more efficiently. Unger (1994) and Baumhardt and Lasecano (1996) reported that FIRB system increased fertilizer uptake efficiently by reducing their losses through leaching and percolation. A study conducted by Singh and Singh (1995) on irrigation efficiency showed that FIRB system of cultivation leads to 25% saving of post sowing irrigation water compared to border strip irrigation. Chauhan et al. (2001) reported that FIRB could reduce the water usage by 25-40% depending on soil type and agro climatic conditions. FIRB system also has been found to reduce the magnitude of weed infestation (Blaylock and Cruse 1992). Pratik Satya (2000) has identified effective tillers per square meter as an important trait of genotypes for grain production under FIRB system.

Selection of appropriate genotypes is essential to harness the full potential of emerging new cost saving agro technology.

Therefore, a study was conducted for three years to select suitable varieties for planting under FIRB system in sandy loam soil of North Bihar.

MATERIALS AND METHODS

A field study was conducted at Research Farm of IARI Regional Station, Pusa, Samastipur (Bihar) during rabi seasons of 1999-2002. The soil of the experimental plot was sandy loam in texture, low in organic carbon (0.41%) available N (158.6 kg/ha^{-1}), P_2O_5 (9.33 kg/ha^{-1}) and K_2O (112.5 kg/ha^{-1}) contents with pH level being 8.4. Eight wheat varieties suitable for timely and late sown conditions of NEP zone PBW 443, HP 1731, HUW 468, HD 2733, HP 1761, UP 262, HP 1633 and HP 1744 were tested in the first year. In second and third year of experimentation four additional varieties PBW 343, HD 2643, K 9107 and PBW 373 recommended for NEP zone were also included for the study. The experiment was laid out in a randomized block design with four replications. The crop was sown on November 26, December 5 and December 31st, respectively,

*Dept. of Agronomy, RAU, Pusa.

Table 1. Yield attributing characters of wheat varieties as influenced by FIRB System of cultivation

Treatment	Number of effective tillers/m ²				Number fo grains/ear				Test weight (gm)			
	1999-00 Y1	2000-01 Y2	2001-02 Y3	Pooled Mean	1999-00 Y1	2000-01 Y2	2001-02 Y3	Pooled Mean	1999-00 Y1	2000-01 Y2	2001-02 Y3	Pooled Mean
PBW 443	285.55	280.33	430.00	331.96	46.82	47.38	37.00	43.73	37.00	36.62	37.00	36.87
HP 1731	294.68	283.83	280.00	286.17	58.62	51.85	49.00	53.15	32.62	32.85	34.50	33.32
HUW 468	271.15	278.91	339.00	296.35	53.92	49.42	48.30	50.55	32.25	32.62	32.00	32.29
PBW 343	-	248.86	336.00	292.43	-	45.50	44.00	44.75	-	38.75	42.00	40.37
HD 2733	315.96	303.20	431.00	350.05	44.97	49.07	46.80	46.95	50.35	47.27	46.50	48.04
HP 1761	245.99	237.24	376.00	286.41	62.67	63.87	63.30	63.28	35.62	33.87	31.50	33.66
UP 262	246.72	240.58	313.00	266.77	51.17	45.42	45.60	47.40	40.70	42.32	40.30	41.10
K 9107	-	230.16	318.00	274.08	-	48.90	41.30	45.10	-	44.62	43.70	44.16
HP 1633	172.22	188.58	288.00	216.27	27.55	29.50	28.50	28.53	29.35	30.62	33.50	31.15
HP 1744	214.20	208.30	299.00	240.50	43.93	38.78	39.50	40.73	39.00	35.00	41.00	38.33
HD 2643	-	216.52	343.00	279.76	-	28.75	35.70	32.22	-	39.35	39.00	39.17
PBW 373	-	297.50	353.00	325.25	-	41.22	39.00	40.11	-	39.60	42.00	40.80
SEm±	2.433	1.951	17.555		2.857	1.840	0.990		0.789	1.245	0.666	
C.D. (P=0.05)	7.16	5.63	50.63		8.41	5.31	2.857		2.32	3.59	1.921	
C.V. %	1.920	1.553			11.734	8.184		4.766	6.588			
Correlation	0.985**	0.740**	0.946**	0.816**	0.788**	0.06NS	0.329NS	0.526*	0.976**	0.617*	0.27NS	0.45NS
Pooled Treatments	Effective no. of tillers			CD (5%)	No. of grains per ear			CD (5%)	Test weight (gm)			CD (5%)
	SEm±				SEm±				SEm±			
Year	5.15		14.34		1.022		NS		0.467			NS
Varieties	10.294		28.67		2.044		5.693		0.934			2.601
Year × Varieties	17.83		49.66		3.540		NS		1.618			NS

during first, second and third year of experimentation. The crop was fertilized @ 90 kg N, 45 kg P₂O₅ and 30 kg K₂O ha⁻¹ i.e. only 75% of the recommended dose of fertilizers for normal wheat in this zone. Full dose of phosphorus, potassium and half dose of nitrogen were applied as basal application at the time of sowing and remaining half of nitrogen was top dressed at first node and late tillering stages in equal splits.

RESULTS AND DISCUSSION

Number of effective tillers

Tillers per square meters differed significantly among the different varieties of wheat under FIRB system as shown in pooled statistical analysis and the result in the individual years (Table 1). Among timely sown wheat varieties, HD 2733 produced maximum number of tillers per unit area in the individual years as well as in pooled analysis. Pooled analysis also showed PBW 443 as the second best variety. Pratik Satya (2000) also found HD 2733, a maximum tillering variety, among 20 varieties tested in Northwest India. Among the late sown varieties PBW 373 produced highest tillers per

unit area followed by HD 2643 in pooled as well as during individual years.

Number of grains per ear

Number of grains per ear was in general higher in timely sown varieties (44 to 63 grains per ear) as compared to late sown varieties (29 to 40 grains per ear), Table 1. Under FIRB system, HP 1761 had highest number of grains per ear followed by HP 1731 and HUW 468 as revealed by pooled statistical analysis and the analysis in individual year. Similarly, HP 1744 and PBW 373 had highest number of gains per ear among the four late sown varieties.

Test weight

Among 12 varieties studied HD 2733 had highest test weight followed by K 9107, UP 262, PBW 373 and PBW 343, having more than 40 gm test weight. Other varieties had test weight between 31-39 gm. In timely sown varieties. HD 2733 had highest test weight and in late sown variety PBW 373 had highest test weight.

Grain yield

Under FIRB system HD 2733, a timely sown variety gave highest mean grain yield of 41.3 q/

Table 2. Mean grain yield q/ha of wheat varieties under FIRB System of cultivation

Varieties	1999-00 (Y1)	2000-01 (Y2)	2001-02 (Y3)	Pooled mean
PBW 443	38.60	34.83	36.00	36.48
HP 1731	43.60	32.07	23.00	32.89
HUW 468	38.20	30.58	27.80	32.16
PBW 343	-	29.43	28.00	28.71
HD 2733	48.80	38.04	37.20	41.34
HP 1761	44.60	26.40	34.80	35.38
UP 262	43.80	29.80	26.40	33.33
K 9107	-	32.70	26.80	29.75
HP 1633	25.60	24.90	21.80	24.10
HP 1744	36.26	31.74	27.80	31.93
HD 2643	-	31.16	29.00	30.08
PBW 373	-	37.02	32.60	34.81
SEm±	0.718	1.153	0.9742	
C.D. (P=0.05)	2.112	3.327	2.810	
C.V. %	3.593	7.310	6.664	
Pooled Treatments	S.E.m±	C.D. (5%)		
Year (Y)	0.483	1.343		
Varieties	0.965	2.689		
Year × Varieties	1.672	4.657		

ha over three years, followed by PBW 443 being at par with HP 1761. Among late sown varieties grown under FIRB system, PBW 373 gave highest mean grain yield of 34.8 q/ha over three years followed by HP 1744 being at par with HD 2643. In both timely and late sown variety, under FIRB system highest grain yield was obtained where the varieties had produced more number of tillers per square meter. In case of variety HP 1761 (timely sown variety) and PBW 373 (late sown variety), the less number of tillers produced per unit area were compensated by more number of grains per ear as compared to the varieties HUW 468 and PBW 343 and late sown variety HD 2643.

Thus, the higher grain yield production in wheat varieties (timely or late sown) under FIRB system was due to higher tillering capacity and its interaction with number of grain per ear where tillering capacity of variety/ies is relatively late.

From the correlation studied also it was evident that most important yield attributing character having maximum direct effect on grain yield was effective number of tillers per plant ($r=0.816^{**}$) followed by grains per ear ($r=0.526^{**}$). Similar positive correlations for number of spike per plant and grains per spike were observed by Chaturvedi and Gupta (1995).

REFERENCES

- Baumhardt, R.L. and Lascano, R.J. 1996. Rain infiltration as affected by wheat residue amount and distribution in ridge tillage. *Soil Sci. Soc. Am. J.*, **60** (6) : 1908-1913.
- Blaylock, a.D. and Cruse, R.M. 1992. Ridge tillage corn response to point injected nitrogen fertilizer. *Soil Sci. Soc. Am. J.*, **56** (2) : 591-595.
- Chaturvedi, B.K. and Gupta, R.P. 1995. Selection parameters for some grain and quality attributes in spring wheat. *Agr. Sci. Digest, Karnal*, **15**(4) : 186-190.
- Chauhan, D.S., Sharma, R.K., Tripathi, S.C., Kharub, A.S. and Chhokar, R.S. 2001 FIRB Technology published in Research Bulletin-8 DWR, Karnal.
- Nigam, A.K. and Gupta, V.K. 1979. Handbook on analysis of agricultural experiments. IASRI Publications. p. 293-307.
- Pratik Satya. 2000. Identification of traits of wheat (*Triticum aestivum*. L.) suitable for Ridge tillage system. Division of Genetics. IARI, New Delhi-110012 (M.Sc. Thesis).
- Sharma, A.K. Singh, C.P., Rane, J. Nagrajan, S. 1998. Alternative selection approaches for targeted cropping sequences. Wheat : Research needs beyond 2000 AD. Proceeding of an international conference 12-14 Aug. 1997 Karnal, India : 1998-227-235.
- Singh, R. and Singh, R. 1995 Development of improved irrigation techniques in wheat crop. *Crop. Res. Hissar.*, **9**(1) : 59-62.
- Unger, P.W. 1994. Ridge tillage for continuation grain sorghum production with limited irrigation. *Soil and tillage Res.*, **31**(1) : 11-12.

STUDIES ON TIME OF ANTHESIS AND DEHISCENCE IN DIFFERENT GENOTYPES OF GUAVA IN WINTER AND RAINY SEASON CROPS

SANJAY SINGH*

Department of Horticulture
Bihar Agricultural College, Sabour, Bhagalpur, Bihar-813210

ABSTRACT

An experiment was conducted to study the time of anthesis and dehiscence on eight years old plants of guava spaced 6×6 m apart in Horticultural Garden of Department of Horticulture, Sabour, during 1998 and 1999. Single plant/unit was replicated 4 times in randomized block design with 10 collections viz., 'Safed Jam' (V₁), 'Kohir Safeda' (V₂), 'Hybrid 1' (V₃), 'Selection - 8' (V₄), 'R₄P₅' (V₅), 'R₅P₃' (V₆), 'R₅P₈' (V₇), 'R₈P₅' (V₈), 'R₁₀P₅' (V₉), and 'Allahabad Safeda' (V₁₀), (check cultivar). Variable percentage of anthesis/dehiscence was registered at the same time in different genotypes. Peak period of anthesis and dehiscence was recorded between 6-8 AM in all the genotypes during both the seasons. None of the genotypes showed anthesis before 4 AM and after 11 AM. Anther dehiscence commenced just after opening of flowers i.e. at 5 AM and continued till 11 AM. None of the genotypes showed anther dehiscence before 5 AM and after 11 AM.

Key words : Anthesis, dehiscence, genotypes, peak period, flowering.

Guava (*Psidium guajava* L.) is considered to be one of the most exquisite and valuable fruits of the tropics. Guava flowers are always borne on newly emerging vegetative shoots irrespective of the time of year (Rathore and Singh 1974, Singh et al., 2000). Consequently, flowering and fruit set can be very erratic depending on the environmental conditions (Singh et al., 2000). In spite of the fact that guava can withstand adverse climate and grow in various types of soil, only a few attempts to improve its varietal wealth had been made in this region. To begin with developments of new varieties the information for anthesis and dehiscence to collect pollen and to emasculate flower is essential. Therefore, studies were undertaken to gather this type of information on guava genotypes under Sabour conditions.

MATERIALS AND METHODS

Eight years old plants of guava spaced 6×6 m apart in Horticultural Garden of Department of Horticulture, Sabour, during 1998 and 1999

Present Address : Senior Scientist (Hort.), CHES (CIAH-ICAR), Vejalpur, Godhra, Panchmahal, Gujarat-389340.

were selected. Single plant/unit was replicated 4 times in randomized block design with 10 collections viz. 'Safed Jam' (V₁), 'Kohir Safeda' (V₂), 'Hybrid 1' (V₃), 'Selection-8' (V₄), 'R₄P₅' (V₅), 'R₅P₃' (V₆), 'R₅P₈' (V₇), 'R₈P₅' (V₈), 'R₁₀P₅' (V₉), and 'Allahabad Safeda' (V₁₀), (check cultivar). To observe the time for anthesis and dehiscence, 50 flower buds expected to open the next days were tagged on the previous evening. The number of fully opened flowers was noted at one hour interval (starting from 4.00 AM in the next morning). Fully opened flowers were marked with delible ink to avoid recounting. Like wise for dehiscence, fully dehiscence anthers were removed to avoid confusion. These observations continued till all the 50 flower buds in each genotype anthesised/dehiscised completely in winter and rainy seasons.

RESULTS AND DISCUSSION

The data indicated that anthesis started at 4 a.m. and continued up to 11 a.m. The optimum time for anthesis was found from 5 to 9 a.m., with the peak period of anthesis from 6 to 8 a.m. in all the genotypes (Table 1). However, least anthesis was recorded between 10 and 11 a.m.

which was accounted to the tune of 0-3% in all the genotypes. It may be considered as negligible. None of the genotypes showed anthesis before 4 a.m. and after 11 a.m. The anthesis was recorded 39.38 and 37% in V₂V₅ and V₄, respectively between 6 to 7 a.m. while V₁₀ (Allahabad Safeda) and V₁ (Safed Jam) recorded 30 and 28% anthesis respectively between 5 to 6 a.m. (Table 1). V₁₀ was the first to show higher rate of anthesis (9.0%) followed by V₁ and V₈ between 4 and 5 a.m. However, delayed anthesis was registered in V₂, V₃ and V₄ i.e. 1.00% each followed by V₅ and V₆ between 4 and 5 a.m. Data pertaining to anther dehiscence (Table 1) indicated that anther dehiscence commenced just after opening of the flower i.e. at 5 a.m. and continued up to 11 a.m. The optimum time for anther dehiscence was from 5 to 9 a.m. with the

peak period of dehiscence being 6-8 a.m. in all the genotypes. None of the genotypes showed anther dehiscence before 5 a.m. and after 11 a.m. It was recorded that V₁₀, V₁, V₆, V₇ and V₉ showed maximum anther dehiscence (42, 40, 33, 34 and 38%, respectively) between 6 to 7 a.m. However, V₂, V₃, V₄, V₅ and V₈ dehiscd 40, 33, 35, 37 and 39% anthers between 7 and 8 a.m. In V₁, V₆ and V₁₀ no anther dehiscd between 10 to 11 a.m., whereas in the remaining, it was 1-3% between 10-11 a.m. The similar pattern was followed for rainy season crop. Peak period of anthesis was recorded between 5 and 8 a.m. in all the genotypes V₁₀, V₉, V₇, V₆ and V₁ showed maximum anthesis (31, 33, 30, 35 and 30% respectively) between 5-6 a.m., while V₈, V₅, V₄, V₃ and V₂ recorded 32, 32, 31, 31 and 32% of anthesis respectively between 6-7 a.m. (Table 2).

Table 1. Time of anthesis and dehiscence in different genotypes of guava in winter season

Genotypes		Flowers opened and anther dehiscd at hourly interval (%)						
		4-5 a.m.	5-6 a.m.	6-7 a.m.	7-8 a.m.	8-9 a.m.	9-10 a.m.	10-11 a.m.
V1	A	8	28	24	21	11	4	2
	D	0	18	40	24	9	2	0
V2	A	1	20	39	22	12	9	2
	D	0	6	30	40	15	6	1
V3	A	1	21	34	21	14	8	2
	D	0	9	23	33	21	8	1
V4	A	1	18	37	23	17	5	1
	D	0	6	23	35	24	8	2
V5	A	3	17	38	22	13	8	1
	D	0	5	31	37	22	7	3
V6	A	4	28	29	20	14	5	0
	D	0	15	33	27	11	3	0
V7	A	5	26	26	20	13	6	0
	D	0	16	34	31	5	3	2
V8	A	7	23	32	21	17	3	2
	D	0	6	28	39	19	5	2
V9	A	6	24	30	24	12	6	2
	D	0	11	38	33	6	4	1
V10	A	9	30	27	24	12	5	0
	D	0	23	42	26	10	2	0

A - Anthesis, D - Dehiscence

V₁₀ was the first to anthesis followed by V₁ between 4-5 a.m. However, at the same time least percentage of anthesis was recorded in V₂ and V₃. It is clear from Table 2 that anther dehiscence commenced just after opening of flowers i.e. at 5 a.m. and continued till 11 a.m. None of the genotypes showed anther dehiscence before 5 a.m. and after 11 a.m. The optimum time for anther dehiscence was found during 5 a.m. to 9 a.m., with the peak period from 6 to 8 a.m. in all genotypes. Balasubramanyam (1959) and Seth (1962) reported that anthesis commenced from early morning i.e. 5-7 a.m. in guava varieties.

However, findings of Dasarathi, (1951), Sehgal (1967) and Teatitia et al. (1971) were not in agreement with the present studies, they reported maximum anthesis during 4-6 a.m. in guava. It might be due to location and varietal characteristics. Dasarathi (1951), Sehgal (1967) and Sandhu et al., (1987) reported that dehiscence in guava varieties took place 15-30 minutes prior to the opening of flowers and the peak period of dehiscence was found between 6-9 a.m. Similar results were obtained by Nalawadi et al. (1973) and Srivastava (1974) in guava cv. L-49 under Dharwad conditions.

Table 2. Time of anthesis and dehiscence in different genotypes of guava in rainy season

Genotypes		Flowers opened and anther dehiscd at hourly interval (%)						
		4-5 a.m.	5-6 a.m.	6-7 a.m.	7-8 a.m.	8-9 a.m.	9-10 a.m.	10-11 a.m.
V1	A	8	30	19	20	12	5	2
	D	0	21	36	26	9	2	1
V2	A	3	29	32	22	13	9	1
	D	0	6	31	37	18	8	1
V3	A	2	24	31	18	13	8	3
	D	0	9	28	36	22	7	1
V4	A	3	18	31	26	11	9	2
	D	0	3	28	37	23	8	1
V5	A	7	25	32	20	16	7	1
	D	0	6	32	38	19	8	1
V6	A	8	35	23	17	12	6	0
	D	0	18	38	28	10	7	1
V7	A	6	30	22	18	14	5	2
	D	0	21	38	30	6	6	1
V8	A	2	22	32	20	17	6	2
	D	0	5	26	37	20	8	1
V9	A	4	33	23	19	12	4	2
	D	0	21	35	27	10	5	1
V10	A	11	31	20	21	13	6	3
	D	0	22	38	28	10	3	1

A - Anthesis, D - Dehiscence

REFERENCES

- Balasubramanyam, V.R. 1959, studies on blossom biology of guava (*Psidium guajava* L.). *Indian J. Hort.*, **16** : 69-75.
- Dasarathy, T.B. 1951. The guava (*Psidium guajava* L.). *Madras Agric. J.*, **30** : 521-24.
- Nalawadi, U.G., Farooqi A.A., Reddy M.A.N., Gubbiah and Nalini A.S. 1973. Studies on floral biology of guava (*Psidium guajava* L.). var. Lucknow 49. *Mysore J. Agric. Sci.*, **7** : 24-37.
- Rathore D.S. and Singh R.N. 1974. Flowering and fruiting in the three cropping patterns of guava. *Indian J. Hort.* **31** : 331-36.
- Sandhu, A.S. Bains, S.S. and Singh, S.N. 1987. Studies on floral biology of guava (*psidium guajava* L.) under ludhiana conditions. 1. flower bud development, time and duration of flowering and floral morphology, *Punjab Hort. J.*, **27** : 203-7.
- Sehgal, O.P. 1967. Studies on blossom biology of guava. (*Psidium guajava* L.). 1. Flowering season, flowering habit, flower bud development, anthesis and dehiscence. *Indian J. Hort.*, **24** : 118-26.
- Seth, J.N. 1962. Floral biological studies in (*Psidium guajava* L.). II. Anthesis and dehiscence of anthers, pollen studies stigma receptivity, fertilization and fruit setting. *Hort. Adv.*, **6** : 110.
- Singh, G. Singh A.K., and Pandey, D. 2000. Effect of cropping patterns on fruiting behavior of guava. *Annals Agric. Research*, **21**(2) : 175-182.
- Srivastava, O..P. 1974. Studies on flowering habit, blooming period, anthesis, dehiscence and pollen grain of *Psidium guajava* L. varieties Apple colour, Chittidar, and Red Fleshed. *Prog. Hort.*, **6** : 71-77.
- Teaotia, S.S. Phagot, K.P.S. and Srivastava, V.S. 1971. Blossom biology studies in *Psidium species*. *Prog. Hort.*, **2** : 101-12.

BALANCE SHEET OF NITROGEN AND PHOSPHORUS AS INFLUENCED BY INTEGRATED PHOSPHORUS MANAGEMENT IN SOYBEAN - WHEAT CROPPING SYSTEM IN SOUTHERN RAJASTHAN

S.P.S. TANWAR*, M.S. SHAKTAWAT AND A.K. VYAS**

*Department of Agronomy, Rajasthan College of Agriculture
Maharana Pratap University of Agriculture and Technology, Udaipur-313001, Rajasthan*

ABSTRACT

Field trials were conducted during 1999-2000 and 2000-01 to workout the balance sheet of nitrogen and phosphorus in soybean-wheat cropping system under the influence of phosphorus (sources and levels), FYM and PSB application. Phosphorus fertilization through either source (URP + SSP and SSP) and increasing levels (30, 60 and 90 kg P_2O_5 /ha) to soybean increased the N status of soil at the end of the cropping system, while a slight decrease in soil P content was recorded. The gains in nitrogen fertility due to increasing levels of phosphorus ranged between 8.7 and 13.7 kg N/ha. Although P application up to 90 kg P_2O_5 /ha to soybean could not maintain the initial P status of soil upto the end of the system but the magnitude of depletion decreased over higher levels. Application of FYM @ 10 tonnes/ha (with and without PSB) improved the N status of the soil but the P status at the end of system was less over initial status. Application of 60 kg P_2O_5 /ha to the succeeding wheat crop maintained the soil P status upto the end of cropping system. Thus, for maintaining proper soil health P fertilization to both the crops was required.

Key words : Integrated phosphorus management, soybean-wheat cropping system, rock phosphate, farmyard manure, phosphate solubilizing bacteria.

Soybean-wheat cropping system has become an important cropping sequence of Southern Rajasthan. Phosphorus nutrition and organic fertilization are now considered imperative for sustainable crop production. Phosphorus helps in nitrogen fixation by increasing soybean-Bradyrhizobium symbiosis and leaving some residual nitrogen in soil, while the crop removes P and K from the soil (Dubey and Srivastava, 1991). The phosphate solubilizing bacteria also increase phosphorus availability from native, fixed and added P after built up of their sizeable population in the presence of organic matter (Gaur, 1990). Conventional phosphatic fertilizers like DAP and SSP are not getting expensive which necessitated to find some cheap indigenous alternate source. In the present investigation, Udaipur rock phosphate + single

super phosphate (1:1) mixtures was tested under the influence of farmyard manure and phosphate solubilizing bacteria against SSP. As all the components of this phosphorus management strategy viz., mineral P fertilizers, FYM and PSB considered to impart residual balance, an attempt has been made to work out balance sheets of N and P after the cultivation of soybean as well as soybean - wheat cropping system as a whole.

MATERIALS AND METHODS

A field experiment was conducted during 1999-2000 and 2000-01 at Rajasthan College of Agriculture, Udaipur. The soil was alkaline (pH 7.8) calcareous clay loam, medium in nitrogen (266.7 kg/ha), available phosphorus (17.22 kg/ha) and rich in available potassium (391 kg/ha). The experiment in soybean crop was laid out in factorial randomized block design with 2 phosphorus sources [URP + SSP (1:1) and SSP], 3 level of phosphorus (30, 60 and 90 kg P_2O_5 /ha) and solubilizers [PSB, FYM @ 10 tones/ha and

*National Bureau of Plant Genetic Resources, New Delhi-110012.

**National Research Centre on Soybean, Indore (Madhya Pradesh).

FYM (10 tones/ha) + PSB] along with two extra treatments of FYM @ 10 tonnes/ha (alone) and absolute control, replicated thrice. In the succeeding wheat crop, split plot design was followed with 20 treatments of soybean (residual in main plot and 2 level of phosphorus (0 and 60 kg P₂O₅/ha) in sub plot. The FYM was incorporated during field preparation as per treatment, while phosphorus was placed in files at the time of sowing. *Bacillus megaterium* var. *phosphaticum* @ 5 g/kg seed was used for seed inoculation as PSB while *Bradyrhizobium japonicum* inoculation was common. A basal dose of 30 kg N/ha to soybean and 120 kg/ha to wheat (in two splits) applied through urea. Soybean (cv. JS 335) was sown at a spacing of 30 cm × 10 cm during second week of July and wheat (cv. Raj 3077) was sown at 23 cm row spacing during mid November. The soil samples (0-15 cm) were collected initial and after the harvest and analysed for available N and P content by Alkaline KMnO₄ method (Subbiah and Asija, 1956) and Olsen's method (Olsen et al., 1954), respectively. Plant samples were also collected and analysed for N and P content using Nessler's reagent colorimetric method (Lindner, 1944) and Vanadomolybdo phosphoric yellow colour method (Richards, 1968), respectively. While preparing the balance sheet, the available nutrient content in FYM at the time of application was also taken into the consideration (Table 1). The data were analysed as average of both the years.

RESULTS AND DISCUSSION

Nitrogen Balance

The balance sheet of available nitrogen under soybean and soybean-wheat cropping system (Table 2) on pooled basis showed a

positive balance in treated plots (column G of Table 2) while there was a depletion of N status of soil as well as less uptake by the crops under absolute control treatment. A higher build up of N was observed under SSP application in soybean crop while at the end of the cropping system although slight, a higher N status was recorded under URP + SSP applied to soybean. With the increase phosphorus application to soybean, build up of nitrogen fertility from 19.2 to 33.0 kg/ha was recorded after the completion of cropping system. Amongst the solublizers, application of FYM @ 10 tonnes/ha with and without PSB markedly improved the soil N status while PSB application (alone) could not maintain even the initial N status of soil nitrogen. The improvement in soil N with the phosphate and FYM application indicate the increased biological nitrogen fixation in plant as well as soil, root mass, root mass, fallen leaf biomass and nutrients released from FYM which were retained in the soil (Gaur, 1990; Dubey, 1997).

Phosphorus Balance

There was a build up of available P in treated plots after the harvest of soybean crop (Table 3). However the residual effect of applied treatment to soybean could not be maintained upto the harvest of succeeding wheat and the available P status in treated plots (residual) decreased by 2.5 kg/ha compared to depletion of only 1.2 kg P/ha under control plots (Table 5). Almost similar build up of available P in soil occurred due to both the sources after soybean and end of the system. Application of 90 kg P₂O₅/ha resulted in increased P status by 10.6 kg P/ha compared to 4.2 kg/ha due to 30 kg P₂O₅ application after harvest of soybean (Table 3). Although the initial P status of soil could not be maintained after the end of soybean but the depletion was least under 90 kg P₂O₅/ha application to soybean (Table 3) and after the harvest of wheat crop the depletion of P status was lesser. Amongst the solubilizers application of FYM with and without PSB improved the soil P status as recorded after the harvest of soybean. This might be due to increased P availability through dissolution of native and applied phosphorus by acidity generated by FYM decomposition thereof less fixation due to

Table 1. Composition of FYM on over dry basis

S.No.	Parameters	Content (%)	
		1999	2000
1.	Dry matter	52.00	56.00
2.	N content	0.46	0.48
3.	P ₂ O ₅ content	0.21	0.23
4.	K ₂ O content	0.53	0.524

Table 2. Balance sheet of available nitrogen (kg/ha) under soybean crop and soybean-wheat cropping system as a whole (on pooled basis)

Treatment	Initial content (a)	Nutrient added (b)	Nutrient removed by crop (c)	Expected nutrient balance (d=a+b-c)	Actually observed (e)	Gain/Loss (f=e-d)	Increase/decrease over initial status (g=e-a)						
Soybean System Soybean System Soybean System Soybean System Soybean System													
A. Soybean													
Control v/s treated													
Control	266.7	30.0	150.0	111.2	197.6	185.5	219.1	217.0	255.0	31.5	35.9	-49.7	-11.7
Treated	266.7	47.4	167.4	173.2	283.8	140.9	150.3	290.9	277.6	150.0	127.3	24.2	10.9
FYM v/s P Mgt.													
FYM (sole)	266.7	55.5	175.5	142.4	241.2	179.8	201.0	237.7	270.6	57.9	69.6	-29.0	3.9
P. Mgt.	266.7	47.0	167.0	175.0	286.1	138.7	147.6	294.9	278.0	156.2	130.4	28.2	11.3
P sources													
URP+SSP	266.7	47.0	167.0	170.3	283.2	143.4	150.5	289.9	279.4	146.5	128.9	23.2	12.7
SSP	266.7	47.0	167.0	179.5	289.1	134.2	144.6	297.7	276.5	163.5	131.9	31.0	9.8
P ₂ O ₅ (kg/ha)													
30	266.7	47.0	167.0	157.8	264.8	155.9	168.9	285.9	275.4	130.0	106.5	19.2	8.7
60	266.7	47.0	167.0	179.7	289.9	134.0	143.8	296.0	278.1	162.0	134.3	29.3	11.4
90	266.7	47.0	167.0	187.2	303.7	126.5	130.0	299.7	280.4	173.2	150.4	33.0	13.7
Solubilizers													
PSB	266.7	30.0	150.0	158.5	259.6	138.2	157.1	280.0	266.1	142.6	109.0	14.1	-0.6
FYM	266.7	55.5	175.5	179.4	294.2	142.8	148.0	298.2	282.0	155.4	134.0	31.5	15.3
FYM + PSB	266.7	55.5	175.5	186.8	304.7	135.4	137.5	302.5	285.8	167.1	148.3	35.8	19.1
B. Wheat P ₂ O ₅ (kg/ha)													
0	266.7	-	166.6	-	269.3	-	164.0	-	275.5	-	111.5	-	8.8
60	266.7	-	166.6	-	289.6	-	143.7	-	277.4	-	133.7	-	10.7

Table 3. Balance sheet of available nitrogen (kg/ha) under soybean crop and soybean-wheat cropping system as a whole (on pooled basis)

Treatment	Initial content (a)	Nutrient added (b)	Nutrient by crop (c)	Expected nutrient balance (d=a+b-c)	Actually observed (e)	Gain/Loss (f=e-d)	Increase/decrease over initial status (g=e-a)						
Soybean System Soybean System Soybean System Soybean System													
A. Soybean													
Control v/s treated													
Control	17.2	0.0	12.9	9.4	31.5	7.8	-1.4	16.0	14.7	8.2	16.1	-1.2	-2.5
Treated	17.2	28.0	40.9	16.2	47.4	29.0	10.7	24.1	16.0	-4.9	5.3	6.9	-1.2
FYM v/s P Mgt.													
FYM (sole)	17.2	5.1	18.0	12.3	38.3	10.0	-3.1	21.1	15.3	11.1	18.4	3.9	-1.9
P. Mgt.	17.2	29.2	42.1	16.4	47.9	30.0	11.4	24.3	16.0	-5.7	4.6	7.1	-1.2
P sources													
URP+SSP	17.2	29.2	42.1	15.8	48.1	30.6	11.2	24.1	16.2	-6.5	5.0	6.9	-1.0
SSP	17.2	29.2	42.1	17.1	47.7	29.3	11.6	24.6	16.0	-4.7	4.4	7.4	-1.2
P ₂ O ₅ (kg/ha)													
30	17.2	16.3	29.2	14.0	43.4	19.5	3.0	21.4	15.6	1.9	12.6	4.2	-1.6
60	17.2	29.2	42.1	17.1	48.2	29.3	11.1	23.9	16.0	-5.4	4.9	6.7	-1.2
90	17.2	42.1	55.0	18.3	52.1	41.0	20.1	27.8	16.6	-13.2	-3.5	10.6	-0.6
Solubilizers													
PSB	17.2	25.8	38.5	14.9	43.6	28.1	12.1	23.2	15.8	-4.9	3.7	6.0	-1.4
FYM	17.2	30.9	43.8	16.9	49.2	31.2	11.8	24.5	16.1	-6.7	4.3	7.3	-1.1
FYM + PSB	17.2	30.9	43.8	17.5	50.8	30.6	10.2	25.2	16.3	-5.4	6.1	8.0	-0.9
B. Wheat P ₂ O ₅ (kg/ha)													
0	17.2	-	26.6	-	41.6	-	2.2	-	14.4	-	12.2	-	-2.8
60	17.2	-	52.4	-	51.5	-	18.1	-	17.5	-	-0.6	-	0.3

formation of phosphohumic complexes (Dutta and Goswami, 1962]. However, a negative balance was recorded after the end of the system. The application of 60 kg P_2O_5 /ha to wheat maintained the initial soil status upto the

end of cropping system. It showed that for maintaining soil health during the soybean-wheat cropping system, along with organic and inorganic P fertilization to soybean, application of 60 kg P_2O_5 /ha to wheat also required.

REFERENCES

- Dubey, S.K. 1997. *J. Indian Soc. Soil Sci.*, **45** : 506.
- Dubey, S.K. and Srivastava, S.K. 1991. *J. Indian J. Agric. Sci.*, **61** : 769.
- Dutta, N.P. and Goswami, N.N. 1962. *J. Indian Soc. Soil Sci.*, **10** : 263.
- Gaur, A.C. 1990. Phosphate Solubilizing Microorganisms as Biofertilizers, pp. 63-90. Omega Sci. Pub., New Delhi.
- Lindner, R.C. 1944. *Plant Physiol.*, **29** : 76.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. 1954. USDA Circular No. 959, Washington, USA.
- Richards, L.A. 1968. USDA Handbook No. 60, USA.
- Subbiah, B.V. and Asija, G.L. 1956. *Curr. Sci.*, **25** : 259.

IDENTIFICATION OF WIDE COMPATIBLE AND MAINTAINER FOR WA-CMS LINES IN RICE (*ORYZA SATIVA* L.)

R. THANGAPANDIAN

Centre for Plant Breeding and Genetics
Tamil Nadu Agricultural University, Coimbatore - 641 003

ABSTRACT

The seven lines were grown along with the eight CMS lines at Coimbatore. Crosses in all combinations between CMS lines and pollen parents were attempted and 56 hybrid combinations were obtained successfully. ADT43, CB97083 were identified as maintainer for IR 58025A, IR68888A, IR69616A, IR70364A, and IR70370A CMS lines. The wide compatibility variety UPR195-170, behaved as a good maintainer to the CMS line IR68887A. The restorer line IR65515-47-2-1-19R was identified as restorer for IR 68887A and IR 68888A CMS lines.

Key words : *Oryza sativa* - CMS lines, maintainer, restorer, spikelet fertility, wide compatibility.

The F_1 hybrids of *indica/japonica* crosses show semi sterility. Some wide compatibility varieties do produce fertile F_1 hybrids when crossed with *indica* as well as with *japonica* varieties. A cytoplasmic male sterile (CMS) line with a wide compatibility gene will be useful in developing *indica/japonica* hybrids that can overcome sterility problems. Developing CMS lines with the wide compatibility gene is to identify these maintainers with the wide compatibility gene into CMS lines by repeated backcrossing as followed for the conversion program in a CMS system.

MATERIALS AND METHODS

The eight CMS lines viz., IR58025A, IR68888A, IR68890A, IR68897A, IR69616A, IR70364A, and IR70370A were crossed with three wide compatibility varieties i.e., UPR195-170, UPR1279-1-4-2, and Pusa 560-2-203-338 and also four elite varieties i.e., ADT43, CB97083, CB98002 and IR65515-47-2-1-19R. 56 F_1 s were screened in test-cross nursery with a spacing of 20/15 cm in 2 m rows in a randomized complete block design with two replications for each test entry during Kharif, 2002 in the research plot of Paddy Breeding Station, Coimbatore.

The main panicles of F_1 plants were bagged.

At the time of anthesis, panicles from individual F_1 plants were collected and anthers of spikelets representing lower, middle and top portions of the panicle branch were smeared in 1% iodine potassium iodine (1-KI) solution and pollen grains were examined under light microscope. The number of deeply stained, fully developed and round pollen grains were counted as fertile. The percentage of pollen fertility was computed as the number of fertile grains by total number observed/100.

Estimation of spikelet fertility

Estimation was done on three panicles per plant; two selected at random and one from the main culm from five randomly selected plants of reach test cross hybrid from each replication at maturity. The number of fertile and sterile spikelets were counted on each panicle and the mean percentage of spikelet fertility was calculated over two replications. On the basis of spikelet and pollen fertility behaviour of F_1 hybrids, lines were classified as restorers (above 80% spikelet and pollen fertility), partial restorers (20-80%), partial maintainers (10-20%) and maintainers (below 10%).

RESULTS AND DISCUSSION

The results of the experiment showed

Table 1. Per cent spikelet fertility for fertility restorer and maintainer classification for WA - CMS lines

WA - CMS lines	Wide Compatibility Varieties			Elite Varieties			
	UPRI 95-170	UPR 1279-1-4-2	Pusa 560-2 -203-338	ADT 43	CB 97083	CB 98002	IR 65515-47 -2-1-19R
IR 58025A	18.00 PM	10.18 PM	20.00PM	0.00M	0.00M	36.40PR	67.20PR
IR 68887A	0.00M	3.25PR	27.80PR	8.10M	18.00PM	30.25PR	81.00R
IR 68888A	18.40PM	10.70PM	19.00PM	0.00M	0.00M	25.25PR	85.00R
IR 68890A	16.10PM	20.00PM	15.70PM	10.12PM	15.60PM	28.10PR	76.50PR
IR 68897A	30.60PR	28.00PR	34.20PR	14.80PM	19.20PM	28.00PR	75.00PR
IR 69616A	12.60PM	6.08M	10.06PM	0.00M	0.00M	24.60PR	70.36PR
IR 70364A	8.00M	7.80M	16.50PM	0.00M	0.00M	18.00PR	78.80PR
IR 70370A	10.80PM	19.60Pm	8.10M	0.00M	0.00M	32.00PR	47.00PR

PR - Restorer; PR - Partial Restorer; PM - Partial Maintainer; M - Maintainer

R - Restorer; PR - Partial Restorer; PM - Partial Maintainer; M - Maintainer

different per cent spikelet fertility (Table 1). Pollen fertility correlated with spikelet fertility. The restorer line, IR65515-47-2-1-19R was identified as restorer for IR68887A and IR68888A CMS lines. This restorer line could be used to develop a new hybrid combinations with IR 68887A and IR68888A CMS lines. ADT 43 and CB 97083 varieties were identified as perfect maintainers for five WA-CMS lines viz., IR58025A, IR68888A, R69616A, IR70364A and IR70370A. Singh *et al.* (1996) identified Radha as maintainer for the CMS line IR58025A. Sarial and Singh (2000) also identified five lines i.e., P615-K-271, P615-K-24, P615-D-11, IET 8320 and UPR87-91 as maintainer for the IR58025A CMS line. The good maintainers, ADT43 and CB97-83 for the WA-CMS lines of IR58025A, IR68888A, IR 69616A, IR70364A and IR70370A are under conversion through a back cross breeding programme to develop the new CMS lines.

The wide compatibility varieties, UPR195-170, UPR1279-1-4-2 and Pusa 560-2-203-338 were identified as partial maintainer for six CMS lines viz. IR58025A, IR68888A, IR68890A, IR69616A, IR70364A and IR70370A. The variety, CB98002 was identified as partial restorer to all CMS lines except IR70364A CMS line. The wide compatibility variety UPR195-170 showed as a good maintainer to IR68887A CMS line. The F_1 s of IR68887A/UPR195-170 revealed 100% pollen sterility and substitution back crosses are being made to develop a new WA-CMS line with wide compatibility gene. Jayamani *et al.* (1998) developed a new CMS line with wide compatibility gene. It was derived from V20A/Dular/Dular (wide compatibility variety) backcross breeding programme. The development of new CMS line with wide compatibility gene could be used to develop the new heterotic three-line *indica/japonica* hybrid combination.

REFERENCES

- Jayamani, P.; K.N. Ganesan; K. Thiyagarajan; M. Rangaswamy, and P. Rangaswamy, 1998. A new CMS line with a wide compatibility gene. *IRRN*, 23(2) : 5.
- Sarial, A.K. and V.P. Singh. 2000. Identification of restorers and maintainers for developing basmati and non-basmati hybrids in rice, *Oryza sativa*. *Plant breed.*, 119 : 243-247.
- Singh, P.K.; R. Thakur.; V.K. Chaudhary and N.B. Singh, 1996. Identification of maintainers and restorers for three CMS lines in rice (*Oryza sativa* L.). *Crop Res.*, 11(1) : 131-132.

RESPONSE OF PEARLMILLET (*PENNISETUM GLAUCUM* L.) HYBRIDS TO ROW SPACING AND NITROGEN APPLICATION

SATISH KUMAR, V.S. KADIAN AND R.C. SINGH

Department of Agronomy
CCS Haryana Agricultural University, Hisar-125 004

ABSTRACT

The field study carried out at Research Farm of CCS Haryana Agricultural University, Hisar for consecutive years, revealed that new pearl millet hybrid HHB 94 significantly out yielded HHB 67 with an increase of 8.7 per cent. Wider row spacing of 45 cm produce significantly more grain and stover yields than 30 cm by a margin of 9.9 and 8.0 per cent, respectively. Application of nitrogen from 60 to 150 kg ha⁻¹ increased the pearl millet yield but significant response was recorded up to 120 kg ha⁻¹ only.

Key words : Pearl millet, hybrids, row spacing, yield and nitrogen levels.

Pearl millet (*Pennisetum glaucum*) as a major kharif cereal generally grown in arid and semi-arid areas and contributes 7.06 million tones to the national pool from an area of 9.81 million hectare. Haryana being a major pearl millet growing state adds 9.35 per cent to the pearl millet production of the country. The potential of newly developed hybrids of pearl millet may only be achieved if optimum plant spacing is adopted with adequate nitrogen supply. Therefore, the present study was planned to find out optimum nitrogen need of pearl millet hybrids in relation to varied planting density.

MATERIALS AND METHODS

The field experiment was conducted during rainy seasons of 2001 and 2002 in the research area of department of Agronomy, CCS Haryana Agricultural University, Hisar. The treatment combinations of two hybrids (HHB 94 and HHB 67) and two row spacing (30 and 45 cm) as main plot treatments and five levels of nitrogen (0, 60, 90, 120 and 150 kg ha⁻¹) as sub plot treatments were tested in split plot design with three replications. The soil of the experimental site was sandy loam in texture, poor in available nitrogen (182 kg), high in available phosphorous (23 kg) and rich in available potassium (432 kg) with slightly alkaline in reaction (8.0). A basal dose

of 60 kg P₂O₅ ha⁻¹ and half of the nitrogen in respective treatment was applied at the time of sowing. Remaining quantity of nitrogen as per treatment was top-dressed at ear emergence. The crop, by using a seed rate of 5 kg ha⁻¹ was sown on 4th July and 26th June in 2001 and 2002, respectively. Extra plants wherever needed were thinned out after 15 days after sowing thereby maintaining a plant to plant spacing of 10 cm. The total rainfall of 347.6 and 45.5 mm was received during the crop period in 1st and 2nd year, respectively.

RESULTS AND DISCUSSION

Performance of hybrids

Hybrids differed significantly for yield and yield attributes. Hybrid HHB 94 produced significantly more grain and stover yields as compared to HHB 67 in both the years (Table 1). Averaged over years, HHB 94 showed an increase of 8.7 per cent over HHB 67. Significantly better development of source in the form of dry matter accumulation, has contributed to the more yield attributes viz. number of ears per meter row length and ear length in this hybrid and effect was reflected in higher yield. However, HHB 67 produced significantly bolder grains compared to HHB 94 in both the years but boldness of grains failed to compensate the yield loss due to lesser number and size of ears.

Table 1. Yield and its attributes of pearl millet as affected by different treatments

Treatments	Plant height (cm)		Dry matter (g/plant ⁻¹)		No. of ear/m.r.l.		Ear length (cm)		Test weight (g)		Grain yield (kg/ha ⁻¹)		Stover yield (kg/ha ⁻¹)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Genotypes														
HHB 94	172.9	180.1	72.67	74.35	15.4	17.6	23.2	25.6	7.39	7.43	1794	2265	6676	8548
HHB 67	162.2	163.1	69.48	72.31	13.8	15.3	20.6	23.3	8.35	8.55	1678	2055	5461	7206
C.D. at 5%	2.9	2.5	1.79	1.85	0.9	1.1	1.2	0.9	0.07	0.09	54	79	197	430
Row spacing														
30 cm	165.3	170.5	68.76	71.22	13.9	15.2	21.1	23.8	7.82	7.79	1668	2045	5979	7432
45 cm	169.7	172.7	73.39	75.44	15.3	17.7	22.7	25.1	7.92	8.21	1804	2275	6158	8322
C.D. at 5%	2.9	NS	1.79	1.85	0.9	1.1	1.2	0.9	0.07	0.09	54	79	197	430
Nitrogen levels (kg ha⁻¹)														
0	150.9	159.3	52.56	55.23	9.7	12.8	18.4	21.3	7.42	7.49	949	1607	4372	6837
60	162.0	167.3	66.50	69.29	13.8	15.3	21.4	24.0	7.80	7.92	1524	1983	5483	7562
90	170.6	174.1	76.88	77.34	15.4	17.0	22.7	25.2	7.95	8.08	1934	2258	6548	8026
120	175.5	177.2	79.08	81.55	16.8	18.5	23.4	25.8	8.06	8.22	2124	2422	6949	8311
150	178.7	180.2	80.32	83.25	17.3	18.7	23.6	25.9	8.11	8.24	2149	2531	6992	8649
C.D. at 5%	3.6	2.8	2.06	2.62	1.3	1.6	1.5	1.1	0.16	0.18	77	116	375	411

Significantly better growth in terms of plant height resulted in increased stover yield of HHB 94 as compared to HHB 67. Similar finding has been reported by Khippal and Hooda, 2002.

Row spacing

A wider row spacing of 45 cm produced significantly more grain and stover yield than narrow row spacing of 30 cm by an average margin of 9.9 and 8.0 per cent, respectively (Table 1). Higher yield under wider row spacing was the resultant of 13.4 per cent more number of ears, 6.5 per cent longer ears and 3.3 per cent bolder grains than narrow row spacing. The better development of yield attributes in wider row spacing might be attributed to proper utilization of natural resources i.e. moisture and nutrients which might have remained under utilized due to mutual plant competition developed by more plants in closer spacing. Singh *et al.* 1992 have also reported higher grain yield at 45 cm row spacing as compared to 30 cm. Higher plant height (1.7%) and more dry matter accumulation (6.3%) in wider row spacing has contributed towards significantly more stover yield in this row spacing compared to narrow spacing. Similar findings have been reported by Nival and Upadhyay, 1979.

Levels of nitrogen

Different levels of nitrogen affected the

yields and its attributes of pearl millet up to significant level. Application of 120 kg N ha⁻¹ produced significantly higher yield over control, 60 and 90 kg N ha⁻¹ but remained at par with 150 kg N ha⁻¹ (Table 1). In general, application of N increased pearl millet yields over no N application in both the years. Each successive dose of N up to 120 kg ha⁻¹ significantly improved the grain yield over its preceding dose. However, the increase in yield by 150 kg N ha⁻¹ could not differ significantly with 120 kg N ha⁻¹. Averaged over years, the increase in yield with 150 kg N ha⁻¹ over control, 60, 90 and 120 kg N ha⁻¹ was 33.4, 11.6 and 2.9 per cent, respectively. Most of the yield attributes viz. number of ears per meter row length ear length and boldness were benefited with the application of N and ultimately it was reflected into increased yield with N application.

Stover yield was significantly increased up to 120 kg N ha⁻¹ in 2001 and up to 90 kg in 2002 (Table 1). However higher dose of 150 kg N ha⁻¹ produced significantly more stover yield over all the preceding levels except 120 kg N ha⁻¹ in both the years. Better plant growth in terms of plant height and dry matter accumulation with different N levels has contributed towards more stover yield of pearl millet. The higher yields of pearl millet with nitrogen have also been reported by Munda *et al.*, 1983.

REFERENCES

- Khippal, A. and Hooda, R.S. 2002. *Haryana J. Agron.*, 18 : 75-77.
 Mahendrapal and Kaushik, S.K. 1972. *Indian J. Agron.* 17 : 169-172.
 Nirval, B.G. and Upadhyay, U.G. 1979. *Indian J. Agron.*, 24(1) : 17-20.

IDENTIFYING POTENTIAL POLLINATORS FOR DEVELOPING HIGH YIELDING HYBRIDS OF PEARLMILLET

V.K. MANGA

Central Arid Zone Research Institute, Jodhpur

ABSTRACT

Eleven newly developed pearl millet (*Pennisetum glaucum* (L.) R. Br. J. pollinators were evaluated for their potential to produce heterotic hybrids by crossing these with three male sterile lines viz., 841A, 91444A in a line $\times$ tester design. Thirty three hybrids so developed and eleven parents were evaluated under arid conditions of Jodhpur. Among lines 814A was the best combiner for grain yield and among testers, CZI 9613-1, and CZI 9621 were good combiners for early vigour, good tillering and grain yield. CZ 9621 however formed the better choice as it was a good combiner for early flowering. Some the potential hybrids identified were 841A $\times$ CZI 9621, 94555A $\times$ CZI 9613-1 and 91444A $\times$ CZI 9621.

Key words : Pearl millet, hybrid, Line $\times$ tester.

In hybrid breeding programme, selection of parents determines the chances of success. Combining ability together with per se performance of parents and hybrids and heterotic response helps a breeder in selecting desirable parents and hybrids. Out of several methods, line $\times$ tester analysis allows testing large number of genotypes. In the present scenario, where pearl millet male sterile lines obtained from other sources are largely used in hybrid development, pollinators have greater scope to play in the exploitation of hybrid vigour and their adaptability to the climatic conditions of the region. In the present study a set of recently developed pollinators were evaluated for their combining ability through line $\times$ tester analysis.

MATERIALS AND METHODS

Eleven pollinators of pearl millet (*Pennisetum glaucum* L.) R.Br. recently developed at the Central Arid Zone Research Institute were used in this study. The pollinators differed in plant height, tillering capacity, days to flowering and grain yield. Pollinators CZI 9626-1 and 9621 were dwarf, while others were medium tall. These pollinators (lines) were crossed with three male sterile lines (testers) 841A, 91444A and 94555A to generate 33 hybrid combinations. These

hybrids along with parents were planted in a randomized block design with three replications at the Central Arid Zone Research Institute, Jodhpur during kharif 1998. Each entry was planted in two rows four meter long and spaced 60 cm apart. the seasonal rainfall was 268 mm and the crop experienced moisture stress at seedling and flowering stage. the data were recorded on early vigour, plant height, days to 50% flowering, productive tillers/plant, ear heads/meter, ear heads/plot, ear length and grain yield per plot. The data were subjected to analysis of variance. Combining ability effects and variances were worked out following Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the entries for all the characters. Hybrids also differed significantly for all traits except for early vigour score. Further partitioning of variation among crosses (Table 1) showed that mean squares due to lines were significant for early vigour score, plant height and ear heads per meter, while mean squares due to testers and line $\times$ testers interactions were significant for all the characters except for early vigour score. The estimates of gca and sca variances indicated that additive genetic variance

played a greater role in the inheritance of plant height whereas dominance variation was more important in the genetic control of productive tillers per plant, days to 50% flowering, ear heads per meter, ear heads per plot, ear length and grain yield. Predominance of additive and additive $\times$ additive gene effects for plant height have earlier been reported by Singh *et al.*, 1980. Predominance of dominant component for grain yield, flowering and ear length have been reported by Singh *et al.*, 1984 and Sahane *et al.*, 1996.

The range and mean of pollinators (Table 2) was higher than the male sterile lines for most of the traits. Pollinators were more vigorous and early in flowering compared to ms lines, but had smaller ear heads. Mean of hybrids was higher over parents for most of the traits except for productive tillers per plant, ear heads per meter, and ear heads per plot for which values were higher over ms lines but lower than pollinators. This could be due to dominance of fewer tillers over high tillering. For days to 50% flowering, the range and mean of hybrids was almost similar to pollinators. Mean heterosis over pollinators varied from -22.6% for ear heads per meter to 174.03% for grain yield, while over ms lines it varied from -44.9% for early vigour score to 324.05% for grain yield. Among pollinators CZI 96/477 recorded the highest grain yield and was closely followed by CZI 9621 and 96/1680. Among hybrids 841A $\times$ CZI 9613-1 and 91444A $\times$ CZI 9621.

The estimates of gca effects for the parental lines given in Table 3, revealed that among ms lines, 941A was the best combiner for grain yield, whereas 91444A was the best combiner for early vigour score, ear heads per plot. Among pollinators CZI 96/1604 was the best combiner for productive tillers per plant, early flowering, ear heads per meter and ear heads per plot. It was however poor combiner for grain yield, plant height and early vigour. CZI 9613-1 and 9621 were good combiners for early vigour, productive tillers per plant, ear heads per meter, ear heads per plot and grain yield. In addition to these traits CZI 9621 was also good combiner for earliness. Another pollinator CZI 96/1657 was

Table 1. ANOVA for line $\times$ tester crosses for different characters in pearl millet

Source	d.f.	Early vigour	Plant height (cm)	Days to flowering	Productive tiller/plant	Ear heads per meter	Ear heads per plot	Ear length (cm)	Grain yield per plot (g)
Crosses	32	0.52	868.3*	52.16**	0.62**	24.68**	655.00**	18.90**	89073.9**
Lines	2	3.39**	1645.3**	0.18	0.06	53.10**	266.5	1.49	34249.8
Testers	10	0.35	2067.3**	120.64**	1.02**	41.51**	1203.46**	41.00**	82111.3**
Line $\times$ Tester	20	0.32	191.03**	23.2**	0.48**	13.42**	419.64**	7.98*	109037.7**
Error	64	0.54	87.67	9.12	0.11	5.69	136.82	3.91	15547.5
α^2A		0.30	317.20	7.10	0.01	6.45	60.00	2.53	-8234.7
α^2D		-0.30	137.81	18.66	0.49	10.30	377.00	5.43	124653.5

*, ** Significant at P = 0.05 and 0.01, respectively.

Table 2. Range, mean and mean heterosis for different characters in pearl millet

	Early vigour	Plant height (cm)	Days to flowering	Productive tiller/plant	Ear heads per meter	Ear heads per plot	Ear length (cm)	Grain yield per plot (g)
Female	Range 3.33-4.67	76.3-91.0	59.3-65.3	1.27-1.43	9.67-12.00	51.0-55.67 *	18.0-24.33	135.3-224.0
	Mean 4.11	85.4	61.3	1.36	10.78	54.11	22.0	159.8
Male	Range 2.67-4.00	70.0-119.3	44.0-66.33	1.37-4.33	9.33-37.67	44.33-161.3	10.33-22.32	163.3-469.0
	Mean 3.55	94.5	54.6	2.40	18.03	86.76	17.15	297.7
Hybrid	Range 1.33-3.00	89.3-152.6	46.0-64.3	1.23-3.47	8.67-20.0	27.67-101.33	20.0-29.0	320.6-998.3
	Mean 2.33	128.3	54.2	1.87	12.11	67.56	24.09	691.8
Mean heterosis (%) over MS lines	-41.90	51.62	-11.70	38.13	12.41	24.91	11.45	324.05
Mean heterosis (%) over pollinators	33.21	33.72	-0.23	-16.80	-22.60	-15.85	46.70	174.03

good combiner for plant height and ear length. Since objective for arid zone would be to develop high yielding, early maturing and good tillering hybrids, CZI 9621 would be a better choice as it was a good combiner for early vigour, earliness, high tillering and grain yield. No correlation was observed between mean grain yield and gca of parents. So per se performance of parents can not be taken as an indicator of their gca.

Among hybrids 94555A × CZI 96/1657, 841A × CZI 96/1604, 91444A × CZ 96/477, 91444A × CZI 893, 841A × CZI 9621, 94555A × CZI 9613-1 and 91444A × CZI 9621 exhibited high sca effects (Table 4). These crosses involved short as well as long duration pollinators. Out of these 841A × CZI 9621 recorded the highest grain yield followed by 94555A × CZI 9613-1, 91444A × CZI 9621 and 91444A × 9613-I. Hybrid 841A × CZI 1604 exhibited significantly high sca effects for eight traits, 91444A × CZI 893 for seven traits and 841A × CZI 9621 and 94555A × CZI 96/1657 for six traits. Hybrids exhibiting desirable sca effects for grain yield also had desirable sca effects for early vigour, plant height, ear length, ear heads per plot and early flowering. Significantly high correlation (0.8294) between mean grain yield of hybrids and their sca effects revealed that per se performance of hybrids can be taken as an indicator of their specific combining ability. Based on these investigations, pollinators CZI 9621 and 9613-I were identified as good general combiners for grain yield. Use of these pollinators in exploiting heterosis for grain yield in pearl millet is suggested.

Table 3. General combining ability effects of parents

Parent	Early vigour	Plant height (cm)	Days to flowering	Productive tiller/plant	Ear heads per meter	Ear heads per plot	Ear length (cm)	Grain yield per plot (g)
841A	0.12	-5.36	0.08	-0.01	0.19	-2.71	-0.21	30.13
91444A	-0.36	-2.64	-0.07	0.05	1.16	-0.25	0.00	3.83
94555A	0.24	8.00	-0.01	-0.03	-1.35	2.96	0.21	-33.96
CZI 9626-1	0.11	-27.30	2.14	-0.01	0.33	1.11	-1.09	-206.25
CZI 26-1	0.11	-20.64	0.25	-0.22	-0.56	1.22	2.58	40.64
CZI 1676-1	-0.22	1.03	-4.86	-0.19	-1.89	-10.00	-1.42	-12.25
CZI 96/477	0.22	9.14	3.25	-0.30	-2.33	-18.00	0.35	-0.3459
CZI 893	0.00	-0.19	2.47	-0.34	-1.44	-17.44	1.24	36.41
CZI 9621	-0.22	-13.64	-4.75	0.29	1.67	14.22	-1.87	127.75
CZI 9613-1	-0.11	10.25	-0.08	0.12	0.89	5.00	-0.20	172.19
CZI 96/1680	-0.33	18.18	4.25	-0.05	-1.11	-0.67	2.46	5.30
CZI 96/1657	0.22	15.25	4.14	0.08	-1.44	3.78	3.02	-83.03
CZI 96/1657	0.22	-4.64	-5.41	0.83	5.22	19.00	-3.65	-50.70
CZI 96/1604	0.22	-4.64	-5.41	0.83	5.22	19.00	-3.65	-50.70
CZI 390-1	0.00	11.92	-1.41	-0.21	0.67	1.78	-1.42	4.53
SE gca (F)	0.09	1.12	0.36	0.04	0.28	1.39	0.24	14.85
SE gca (M)	0.20	2.49	0.80	0.09	0.64	3.12	0.53	33.21

Table 4. Mean performance, specific combining ability accets and per cent heterosis for grain yield of some promising hybrids of pearl millet

Hybrid	Grain yield (g/ plot)	SCA	% heterosis
841 A × CZI 9621	978	128.7	211.4
94555 A × CZI 9613-1	955	124.9	518.8
91444 A × CZI 9621	918	118.3	229.8
91444 A × CZI 9613-1	909	50.8	468.3
841 A × CZI 96/1604	903	232.4	327.9
91444 A × CZI 893	888	156.0	355.0
94555 A × CZI 1657	845	270.2	291.8
91444 A × CZI 96/477	909	298.3	193.8

REFERENCES

- Kemphorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, Inc. New York.
- Sahane, D.V., Tetali, S., Kuldarni, V.M. and Wattamwar, M.J. 1996. Combining ability of newly developed restorers in Pearl millet. *Maharashtra Journal of Agric. Res.*, **21** : 42.
- Singh, J.N., Pokhriyal, S.C., Murthy, B.R. and Patil, R.P. 1984. Combining ability in pearl millet. *Indian J. Agric. Sci.*, **54** : 175.
- Singh, V.P., Kumar, S., Tiwari, S.N. and Chauhan, B.P.S. 1980. Combining ability analysis for yield and its components in pearl millet. *Indian J. Genet.*, **40** : 276.

IMPLICATIONS OF ORGANIC MANURE, NITROGEN AND POTASSIUM APPLICATIONS IN WHITE YAM (*DIOSCOREA ROTUNDATA* POIR) INTERCROPPED IN COCONUT GARDEN ON NUTRIENT BALANCE OF SOIL

G. SUJA*, V.M. NAIR, R. SARASWATHY AND J. SREEKUMAR**

College of Agriculture, Vellayani
Thiruvananthapuram-695017, Kerala.

ABSTRACT

The influence of three organic manures (farm yard manure, coir pith compost, in situ green manuring using sunhemp) and three levels each of N, P and K (40, 80, 120 kg ha⁻¹) on balance sheet of available N, P and K contents of soil in white yam intercropped in coconut garden was studied for two years (1998-2000) at College of Agriculture, Vellayani, Thiruvananthapuram. Available N, P and K contents of soil showed deficit balance at the end of two years of experimentation. Green manuring enhanced the available N, P and K status of the soil profoundly and lowered the net losses incurred in the balance sheets. Addition of higher rates of N and K favoured greater loss of the respective nutrients. However, the enhanced supply of one nutrient led to reduction in the loss of the other nutrient.

Key words : White yam, intercrop, coconut garden, organic manures, nitrogen, potassium, available N, P, K balance.

African white yam (*Dioscorea rotundata*) a recent introduction to India is gaining popularity due to its high yield potential, acceptable tuber quality, especially high dry matter and starch contents, good taste and feasibility in diverse cropping systems (Nair et al., 1987; Nayar and Suja, 1996; Nayar and Suja, 1999). Yams perform well in soils rich in organic matter and nutrients. Apparently higher response to applied N and K and poor response to phosphorus has also been confirmed (Lyonga, 1982; Kabeerathuma et al., 1987). Fertilization is not a current practice in yams. The high soil exhausting nature of *D. rotundata* (Kabeerathuma et al., (1987) and negligible recycling of nutrients through crop residues (Kabeerathuma et al., (1991) necessitates continuous replenishments of the soil with organic manures and fertilizers. The organic manurial recommendation for yam is also slightly high (10 t ha⁻¹) and farmyard manure (FYM) is

the chief organic source currently used. The non-availability, high cost and drudgery in transportation and spreading of FYM discourage many farmers from using it. Hence the feasibility of using alternative organic manures viz., coir pith compost; green manuring in situ using sunhemp etc. and their impact on nutrient balance sheet needed exploration. Hence the present investigation was taken up to study the effects of organic manures, nitrogen and potassium on the nutrient balance of the soil in white yam intercropped in coconut garden.

MATERIALS AND METHODS

Field experiments were conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram during May-February in 1998-99 and 1999-2000 on red loam soils classed as Rhodic haplustox. Texturally the soil is a clay loam with acidic soil reaction (pH 5.62), low contents of available N (266.87 kg ha⁻¹) and available K (137.84 kg ha⁻¹), medium content of organic carbon (0.529%) and high content of available phosphorus (61.58 kg ha⁻¹). The initial contents of total N, P and K were 0.078%, 0.056% and 0.026% respectively. The climate of the test

Present Address : *Division of Crop Production, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala-695017.

**AICRP on tuber crops, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala-695017.

site is humid tropical with mean annual precipitation of 1899 mm, relative humidity of 83.50% and maximum and minimum air temperatures of 30.3°C and 23.4°C respectively.

The experiment was laid out as a split plot design with 30 treatments replicated twice. Three sources of organic manures (viz., FYM @ 10 t ha⁻¹ (o₁), coir pith compost @ 5 t ha⁻¹ (o₂) and in situ green manuring using sun hemp (o₃) were assigned to main plots, combination of three levels each of N (n₁, n₂, n₃) and K (k₁, k₂, k₃) i.e., (40, 80, 120 kg ha⁻¹) apart from zero N zero K (control) comprised the sub plot treatments.

The coconut palms in the garden selected for the experiment were spaced at 7.5 m and were 25-30 years of age. "Sree Priya", a selection of white yam (*D. rotundata*) released from Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram was used for the study. Plots of size 7.2×3.6m² were formed in the inter spaced of coconut trees leaving an area of 2 m radius from the base of the palms. Field culture as per the package of practices recommendations (KAU, 1996) were followed. The plants were trailed 15 days after sprouting using coir ropes tied to galvanised iron wires connecting coconut trees. Observation plants were trailed individually.

Seeds of green manure sunhemp were sown @ 35 kg ha⁻¹ in the interspaces of pits reformed into mounds on the succeeding day of planting yams and incorporated at 60 days after sowing in small basins taken around the mounds. Sunhemp seeds were sown again following the same field culture and incorporated 45 days thereafter. The green matter obtained from each plot was also quantified before incorporation.

Mussoriephos to supply a constant dosage of 60 kg ha⁻¹ P₂O₅ was applied. The whole of P₂O₅, half the dose of N and K were given within a week after sprouting of yam. After one month, the remaining doses of N and K were applied along with weeding and earthing up. Plots assigned for green manuring received full P₂O₅ (60 kg ha⁻¹) at presowing of sunhemp. Half the doses of N and K were applied at the time of first incorporation of green matter, but before

the second sowing. The remaining doses of N and K were applied one month later. The crop was mainly rainfed and harvested after 9 months.

Nutrient balance were worked out for available N, P₂O₅ and K₂O in each year as per the procedure outlined by Sadanandan and Mahapatra (1973a).

RESULTS AND DISCUSSION

Available N balance

Available N showed a net negative balance in both the years, however lower net losses were discernible in the second year (Table 1). The results support the finding of Sadanandan and Mahapatra (1973a). The net loss or gain of N was arrived at by deducting the expected N balance in the soil from the actual N balance or available N content of the soil. Though the soil of the research site was rated as low for available N content, slightly higher soil test values at the establishment of the experiment in 1998 as compared to that of 1999 resulted in higher expected nutrient balance in all the treatments but the corresponding actual nutrient balance was considerably lower which led to lower net loss of N. High mobility of N and its rapid loss through leaching and volatilization are other factors to explain the net loss incurred in the balance sheet for nitrogen. However, at the commencement of second season experiments in 1999 the available N content was substantially lower than that at the establishment of the experiment in 1998. This factor coupled with comparatively greater addition through green manure, slightly lesser crop removal on accounts of lower tuber yield and lower leaching loss due to the low receipt of rainfall during the second year resulted in comparatively lower net losses of available N in all the treatments in 99-00.

During both the years comparatively lower net loss of N was observed in sunhemp-incorporated plots. Several reports have indicated net gains of N in crop sequences involving legumes/green manures viz., groundnut - jute - rice (Sadanandan and Mahapatra, 1973a), soybean - wheat (Raghuwanshi et al., 1991) and Dhaincha - wheat (Binod Kumar et al., 2000). The apparent lower

Table 1. Available nitrogen balance

Treatments	Initial status (kg ha ⁻¹)		N addition (kg ha ⁻¹)		N uptake (kg ha ⁻¹)		Expected balance (kg ha ⁻¹)		Available N status (kg ha ⁻¹)		Net loss/gain (kg ha ⁻¹)	
	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00
o ₁	264.68	196.04	122.00	122.00	61.66	57.95	325.02	260.09	196.04	190.88	-128.98	-69.21
o ₂	264.58	201.90	140.00	140.00	76.54	70.88	328.05	271.01	201.90	201.32	-126.15	-69.70
o ₃	264.48	206.54	91.19	110.35	64.80	60.48	290.87	256.41	206.54	201.61	-79.84	-54.80
n ₁	264.63	187.84	88.22	94.75	62.93	56.25	289.92	226.34	187.84	190.18	-97.41	-36.17
n ₂	263.75	214.34	125.15	132.20	76.50	67.96	312.40	278.57	214.34	206.60	-98.06	-71.97
n ₃	265.54	215.30	164.94	170.58	75.82	73.92	354.66	311.96	215.30	210.79	-139.35	-101.16
k ₁	263.49	205.96	124.48	134.86	73.75	64.28	315.95	276.54	205.96	205.33	-110.00	-71.22
k ₂	265.22	205.96	124.48	134.86	73.75	64.28	315.95	276.54	205.96	205.33	-110.00	-71.22
k ₃	265.20	221.36	124.78	130.93	76.20	72.78	313.79	279.52	221.36	214.34	-92.43	-65.18
n ₁ k ₁	263.34	169.21	99.00	91.62	54.42	49.37	307.91	211.46	169.21	179.85	-121.10	-31.61
n ₁ k ₂	261.86	188.55	84.04	98.91	64.40	53.08	281.50	234.38	188.55	196.32	-92.95	-38.06
n ₁ k ₃	268.68	205.76	85.21	93.73	69.96	66.30	283.93	233.19	205.76	194.36	-78.17	-38.83
n ₂ k ₁	263.46	204.03	125.26	131.58	71.37	63.17	317.36	272.43	204.03	188.55	-113.33	-83.88
n ₂ k ₂	266.59	219.49	124.96	134.89	80.08	71.73	311.47	282.65	219.49	207.89	-91.98	-74.76
n ₂ k ₃	261.20	219.49	125.24	130.13	78.06	68.99	308.38	280.63	219.49	223.37	-88.89	-57.26
n ₃ k ₁	263.67	197.25	166.47	171.99	70.11	70.72	360.03	298.53	197.25	195.32	-162.77	-103.21
n ₃ k ₂	267.21	209.83	164.45	170.79	76.77	68.02	354.89	312.60	209.83	211.76	-145.06	-100.84
n ₃ k ₃	265.73	238.83	163.90	168.94	80.58	83.03	349.05	324.74	238.83	225.30	-110.22	-99.45
n ₀ k ₀	264.07	162.45	41.38	48.59	30.91	36.61	274.54	174.43	162.45	156.64	-112.09	-17.79

net loss of N in green manured plots in the present study may be due to the less susceptibility of N derived from green manure to leaching than fertilizer N on account of slow release of N from green manure. Furthermore, the incorporation of green manure at times when the yam crop had put forth sufficient canopy growth facilitated synchrony in the rate of N mineralization with that of N uptake by the crop and reduced the substantial loss of N from the soil - plant system enhancing the efficiency of green manure - N. Lastly, addition from biological N fixation though considered negligible might have also helped in promoting the N status of the soil. Increasing levels of N tended to enhance the N losses in both the seasons. Sadanandan and Mahapatra (1973a) also observed that the rate of N loss increases as the quantity of applied fertilizers and manures increases. On the other hand incremental doses of potassium reduced the loss considerably due to better utilization of N. Similar trends were observed due to the interaction effect, $N \times K$. In general, at all levels of N, higher rates of K reduced the net loss of N. It is also obvious that the highest dose of N indicated greatest loss, irrespective of the levels of K.

Available P balance

Deficit balance sheet for available P was noticed in all the treatments in 98-99 as well as in 99-00 (Table 2). Sadanandan and Mahapatra (1973b) and Raghuwanshi et al. (1991) also reported similar results. Major portion of P added as manures and fertilizers might have undergone reversion. The rate of release of P from mussooriephos is very slow and the crop might have absorbed whatever quantity released and the remaining P might have existed in the unavailable form in the soil. Further temporary conversion of mineralized inorganic form to organically bound ligands might have reduced the available P status to the present crop, though the same in available in the long run (Russell, 1973). Hence the actual P balance could never been up to the expected P balance which is theoretically computed on the assumption that 100% mineralization of organic P takes place. The higher test value for available P at the initiation of the experiment also might have further

enhanced the expected P balance. These factors led to negative balance sheet for available P. However considerable decrements in net losses were observed in 99-00 since there was slight increase in the content of available P at the end of second crop cycle compared to that at the start of the research.

Of the organic manures tried, incorporation of sunhemp resulted in comparatively lower losses in both the seasons. The greater mineralization of organically bound P consequent to decomposition of sunhemp could have enriched the available pool of phosphorus and lowered the magnitude of net loss of P.A. declining trend in the net loss of P was observed with increasing levels of N and K in the first season due to better utilization of P at higher rates of N and K. However in the subsequent year, higher rates of N slightly enhanced the net loss of P due to higher N/P ratio wherein the increased supply of N might have limited the mineralization of organic P as pointed out by Tisdale et al. (1995). Considering the $N \times K$ interaction, irrespective of the levels of N, higher rates of K reduced the net deficit in both the years.

Available K balance

The available K status of the soil was in general enhanced in most of the treatments in the first year leading to positive K balance (Table 3). However in the succeeding year, negative balance for K was observed (Table 3). The magnitude of loss was comparatively lesser than that of N and P. When compared to the initial soil test value for available K, available K status observed at the start of the second season experiment was higher and thus the expected K balance was higher for that year. Moreover, the actual K content of the soil was not as high as the theoretically computed expected K balance was higher for that year. Moreover, the actual K content of the soil was not as high as the theoretically computed expected K balance of the soil, which led to greater losses of K.

In 98-99, a distinct gain in the quantity of available K or in other words positive K balance was observed due to green manuring as a result of greater release of K^+ in soil solution from the

Table 2. Available phosphorus balance

Treatments	Initial status (kg ha ⁻¹)		P addition (kg ha ⁻¹)		P uptake (kg ha ⁻¹)		Expected balance (kg ha ⁻¹)		Available N status (kg ha ⁻¹)		Net loss/gain (kg ha ⁻¹)	
	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00
O ₁	63.37	56.12	80.00	80.00	6.88	7.01	136.50	129.11	56.12	57.85	-80.38	-71.26
O ₂	62.44	66.56	63.00	63.00	8.44	7.65	117.01	121.90	54.20	61.07	-62.81	-60.84
O ₃	62.33	54.24	61.40	63.65	6.87	7.12	116.86	110.77	66.65	67.75	-50.21	-43.02
n ₁	64.37	56.94	68.07	69.12	7.09	7.01	125.34	119.06	56.94	64.25	-68.40	-54.81
n ₂	61.18	60.44	68.22	68.89	8.16	7.62	121.24	121.71	60.44	63.08	-60.80	-58.63
n ₃	61.78	60.72	68.20	68.74	8.21	8.24	121.77	121.22	60.72	61.94	-61.05	-59.27
k ₁	61.80	55.49	68.15	68.85	7.02	6.58	122.93	117.75	55.49	61.26	-67.44	-56.49
k ₂	62.86	60.32	68.16	69.14	8.10	7.46	122.92	122.00	60.32	62.05	-62.60	-59.95
k ₃	62.67	62.30	68.19	68.77	8.35	8.83	122.51	122.24	62.30	65.97	-60.21	-56.27
n ₁ k ₁	63.03	50.39	67.86	68.84	5.94	6.00	124.96	113.23	50.39	60.60	-74.57	-52.63
n ₁ k ₂	63.98	58.94	68.11	69.53	7.41	6.97	124.68	121.50	58.94	64.02	-65.75	-57.48
n ₁ k ₃	66.09	61.50	68.23	69.04	7.93	8.07	126.39	12.47	61.50	68.14	-64.89	-54.33
n ₂ k ₁	61.57	58.55	68.23	68.83	7.68	6.48	122.13	12.90	58.55	61.22	-63.58	-59.68
n ₂ k ₂	62.47	61.81	68.20	69.15	8.41	7.56	122.26	123.40	61.81	62.99	-60.45	-60.40
n ₂ k ₃	59.50	60.97	68.23	68.69	8.39	8.82	119.34	120.84	60.97	65.03	-58.37	-55.82
n ₃ k ₁	60.79	57.53	68.35	68.87	7.43	7.27	121.70	119.13	57.53	61.96	-64.18	-57.17
n ₃ k ₂	62.13	60.22	68.15	68.76	8.47	7.86	121.81	121.11	60.22	59.13	-61.59	-61.98
n ₃ k ₃	62.42	64.42	68.10	68.58	8.73	9.59	121.79	123.41	64.42	64.74	-57.37	-58.66
n ₀ k ₀	65.14	55.40	67.86	68.55	3.56	3.99	129.45	119.96	55.57	64.39	-73.88	-65.57

Table 3. Available potassium balance

Treatments	Initial status (kg ha ⁻¹)		K addition (kg ha ⁻¹)		K uptake (kg ha ⁻¹)		Expected balance (kg ha ⁻¹)		Available N status (kg ha ⁻¹)		Net loss/gain (kg ha ⁻¹)	
	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00
o ₁	134.45	162.51	112.00	112.00	61.62	60.38	184.83	214.13	162.51	158.97	-22.32	-55.16
o ₂	133.17	163.61	127.00	127.00	79.05	70.93	181.12	219.68	163.61	165.51	-17.51	-54.17
o ₃	134.71	182.83	83.29	63.65	65.97	61.99	152.03	184.49	182.83	168.13	30.80	-16.37
n ₁	135.10	171.70	114.91	106.47	64.80	58.73	185.20	219.44	171.70	158.42	-13.50	-61.02
n ₂	132.21	181.43	116.14	106.22	78.67	67.68	169.68	219.98	181.43	168.33	11.75	-51.65
n ₃	134.23	169.09	115.97	106.07	75.67	77.46	174.53	197.69	169.09	179.67	-5.44	-18.02
k ₁	134.19	128.72	75.54	79.51	64.80	59.57	144.93	148.67	128.72	139.763	-16.20	-8.91
k ₂	133.26	188.94	115.62	106.48	75.23	68.05	173.65	227.37	188.94	177.92	15.29	-49.46
k ₃	134.10	204.55	155.85	132.77	79.12	76.25	210.83	261.07	204.55	188.75	-6.28	-72.32
n ₁ k ₁	135.65	123.65	73.26	79.50	55.16	49.78	153.75	153.38	123.65	125.99	-30.09	-27.39
n ₁ k ₂	135.41	192.77	115.28	106.86	65.86	56.45	184.84	243.19	192.77	177.43	7.94	-65.76
n ₁ k ₃	134.24	198.67	156.18	133.04	73.39	69.96	217.03	261.75	198.67	171.85	-18.35	-89.90
n ₂ k ₁	131.76	128.19	76.22	79.50	71.88	59.05	136.10	148.63	128.19	153.85	-7.91	5.22
n ₂ k ₂	131.71	194.48	115.99	106.48	82.03	72.92	165.67	228.04	194.48	167.17	28.81	-60.87
n ₂ k ₃	133.17	221.63	156.21	132.69	82.11	71.06	207.27	283.26	221.63	183.97	14.36	-99.29
n ₃ k ₁	135.15	134.33	77.15	79.54	67.36	69.86	144.94	144.01	134.33	139.44	-10.60	-4.57
n ₃ k ₂	132.65	134.33	77.15	79.54	67.36	69.86	144.94	144.01	134.33	139.44	-10.60	-4.57
n ₃ k ₃	134.88	193.36	155.18	132.58	81.85	87.75	208.21	238.19	193.36	210.43	-14.85	-27.77
n ₀ k ₀	136.48	129.83	33.24	52.55	31.36	32.73	138.36	149.65	129.83	122.75	-8.53	-26.90

insoluble K minerals by organic acids or carbon dioxide formed during green manure decomposition and due to greater recycling of subsurface K (Table 3). In the second year, the general observed trend of net loss of K (negative balance) though reflected in the green manured plots also was considerably reduced due to beneficial effects of green manuring on available K (Table 3). Medium levels of N and K maintained net gains in the first year. In the next year, incremental doses of N tended to reduce the net loss due to build up of available K at higher rates of N (Table 3). However, higher potassium nutrition favored greater losses in the second year due to the reasons already stated by Sadanandan and Mahapatra (1973a).

The results of the nutrient balance sheet studies indicate that excessive leaching and mineralization under the influence of high rainfall (mean annual rainfall during the experimental period of 1899 mm), slightly greater nutrient uptake by the yam crop than the net available reserve excluding losses, negligible recycling of nutrients from the vegetative parts for the current season crop, low cation exchange capacity and organic matter status of the soil and the impossibility to achieve the theoretical rate of mineralization from the organic sources in coconut garden under partial shade might have led to negative net changes in the available status of N, P and K and resulted in deficit balance sheets for these nutrients.

REFERENCES

- Binod Kumar, Roysharma, R.P. and Singh, S.B. 2000. Balance sheet of soil nitrogen in wheat (*Triticum aestivum*) based crop sequence. *Indian J. Agron.*, **45** : 227-231.
- Kabeerathumma, S., Mohankumar, B. and Nair, P.G. 1987. Nutrient Uptake and Their Utilization by Yams. Aroids and Coleus. Technical Bulletin Series 10, CTCRI, Thiruvananthapuram, 34 pp.
- Kabeerathumma, S., Mohankumar, B. and Nair, P.G. 1991. Nutrient uptake and their utilization pattern by yams at different growth stages. *J. Root Crops*, **17**(1) : 26-30.
- KAU. 1996. Kerala Agricultural University. Package of Practices : Recommendations. Crops. 1996, Directorate for Extension, Mannuthy, Thrissur. pp. 50-52.
- Lyonga, S.N. 1982. Agronomic effects and economic importance of fertilizer on yams in Cameroon. In : *Root Crops in Eastern Africa*, International Development Research Centre, Ottawa, Canada, pp. 81-85.
- Nair, S.G., Abraham, K. and Nayar, G.G. 1987. Two high yielding selections of white yam (*Dioscorea rotundata* Poir.). *J. Root Crops*, **13**(2) : 103-109.
- Nayar, T.V.R. and Suja, G. 1996. Intercropping *Dioscorea* with banana var. Neendran (Musa, AAB). *J. Root Crops*, **22**(2) : 115-120.
- Nayar, T.V.R. and Suja, G. 1999. Plant density for intercropping *Dioscorea* in coconut gardens. In : *Tropical Tuber Crops : In Food Security and Nutrition*, (Ed.) Balagopalan, C., Nayar, T.V.R., Sundaresan, S., Premkumar, T. and Lakshmi, K.R. Oxford & IBH Publishing Co. Private Ltd., New Delhi, pp. 351-356.
- Raghuwanshi, R.K.S., Umat, R., Nema, M.L. and Dubey, D.D. 1991. Balance sheet of nitrogen, phosphorus and potash in soil as influenced by wheat (*Triticum aestivum*) based crop sequences. *Indian J. Agron.*, **36** : 322-325.
- Russell, E.W. 1973. *Soil Conditions and Plant Growth*. 10th edn. Longman Group Ltd., London, 849 pp.
- Sadanandan, N. and Mahapatra, I.C. 1973a. Studies in multiple cropping-balance sheet of nitrogen in various cropping patterns. *Indian J. Agron.*, **18** : 323-327.
- Sadanandan, N. and Mahapatra, I.C. 1973b. Studies on multiple cropping balance sheet of total and available phosphorus in various cropping patterns. *Indian J. Agron.*, **18** : 459-463.
- Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1995. *Soil Fertility and Fertilizers*, 5th edn. Prentice Hall of India Private. Ltd., New Delhi, 638 pp.

STUDIES ON PEROXIDASE IN JUTE BARK TISSUE

FALGUNI DAS¹, SATYAKINKAR PAL¹ AND KRISHANU CHAKRABARTI^{2*}

¹Institute of Agricultural Science
Department of Plant Physiology, Calcutta University, 35,
Ballygunge Circular Road, Kolkata - 700 019

²Department of Biochemistry
Calcutta University, 35, Ballygunge Circular-Road,
Kolkata-700019

ABSTRACT

Peroxidase activity was examined in the bark of different varieties of jute plant (*Corchorus olitorius* L.). Lignin content and peroxidase activity were positively correlated. Jute peroxidase utilized o-dianisidine, NADH, coniferyl alcohol and syringaldazine as substrates. Activity with syringaldazine (typically used to detect lignifying activity) was much higher than with the other substrates. On PAGE analysis only one band was obtained from all samples regardless of high or low peroxidase activity. The difference that emerged was at the level of band intensity.

Key words : Peroxidase, lignin, PAGE.

Jute fibre is bastose or lignocellulosic in nature. Chemically lignin is a polymer composed of monolignol units of cinnamyl, p-coumaryl, coniferyl and sinapyl alcohol (Lewis and Yamoto, 1990). The last step in the polymerization (lignification) of such monolignols is catalyzed by plant peroxidases and has been extensively studied (Biles *et al.* 1982; Evans *et al.* 1991). A temporal correlation between lignification and alkaline apoplastic peroxidase activities in shoot axis and needles of spruce (*Picea abies* L.) was reported by Polle *et al.* (1994), while a decrease in peroxidase activity accompanied by reduced lignification was observed by Cowles *et al.* (1989) and several species of Pinus. The lignifying peroxidases have been characterized by their ability to oxidase coniferyl alcohol or syringaldazine where as the non-specific peroxidase activity has been assayed with substrate such as guaiacol, o-dianisidine etc. (Polle *et al.* 1994). The relative lignin content of the stem, in Eucalyptus was closely associated with peroxidase and coniferyl oxidase activity (Chakrabarti *et al.* 2000). Pedreno *et al.* (1999) have presented evidence for the direct involvement of peroxidase activity in lignifying xylem. Studies on peroxidases in jute and their possible relationship vis-a-vis lignin content have

not been undertaken till date. In the context of the above background the present investigation has been focused on :

- i. Peroxidase activity in jute bark tissue
- ii. characterization of the activity using various substrates
- iii. PAGE analysis of jute bark peroxidase
- iv. Lignin content as a function of Px activity

MATERIALS AND METHODS

Plant materials used in the present study were collected from ninety days old *Corchorus olitorius* from the Central Research Institute for Jute and Allied fibres (CRIJAF), Nilganj Barrackpur, West Bengal. From the middle of the selected plants 10 cm long portion of stem was taken and preserved at -20°C. The barks of the preserved samples were used for subsequent analysis. A total of twenty varieties were used for the present investigation. Peroxidase activities were measured in all the samples using o-dianisidine. On the basis of high and low peroxidase activity six varieties were selected for analysis of substrate specific activity using syringaldazine, NADH and coniferyl alcohol,

Table 1. Expression of substrate specific peroxidase (s) in jute bark

Variety	Substrate activity (U/gfw)			
	o-diansidien	syringaldazine	coniferyl alcohol	NADH
JRO-620	13.27 ± 0.53	15.51 ± 0.776	7.20 ± 0.216	2.91 ± 0.145
TAN/SM/040C	10.75 ± 0.43	14.09 ± 0.596	6.56 ± 0.328	2.42 ± 0.072
TAN/X/112C×THA/YA/064C	12.47 ± 0.622	14.81 ± 0.74	7.12 ± 0.356	2.62 ± 0.131
CMU-013×JRC-321	2.12 ± 0.106	4.82 ± 0.192	2.70 ± 0.135	0.337 ± 0.016
CMU-011×JRO-524	3.71 ± 0.148	5.31 ± 0.265	3.07 ± 0.123	0.675 ± 0.033
CMU-012×JRC-321	4.19 ± 0.209	6.86 ± 0.343	3.12 ± 0.156	0.70 ± 0.0288

lignin content and isozyme pattern on gel-electrophoresis. Peroxidase was extracted and assayed following the method of Chen and Asada (1989) with certain modification (Das *et al.*, 1999). Activity with NADH was observed by polyacrylamide gel electrophoresis (PAGE) following the method of Mittal and Dubey (1991). Enzyme staining was carried out by immersing the gels in an incubation mixture containing sodium phosphate buffer (100mM, pH-6.5), o-diansidine (20 mM) and H₂O₂ (5mM).

RESULTS AND DISCUSSION

Peroxidase activity ranges from (13-.2 U/gfw) in the total (20) sample population (data not shown). Figure 1a and 1b shows the peroxidase activity and lignin content in the bark of jute plants selected on the basis of high and low peroxidase activity. Lignin content showed a concomitant rise with peroxidase activity. The observation that higher peroxidase activity is related to higher lignin content and vice-versa, was in keeping with the observation of mader and Amberg-Fisher (1982), that plant peroxidase (s) catalyze two separate reactions that lead to polymerization of monolignol precursors into lignin. The above observation was also supported by the study in many *Pinus sp.*, where decreased peroxidase activity was accompanied by reduced lignin deposition (Cowles *et al.* 1989). In a recent investigation, Chakraborty *et al.* (2001) found the same relationship between peroxidase and lignin content in *Eucalyptus sp.* The activity of jute

peroxidase with different substrates is shown in Table 1. Peroxidase activity in the bark utilized o-diansidine (a non-specific substrate), syringaldazine and coniferyl alcohol. Activity with syringaldazine was much higher than any other peroxidase activity. Syringaldazine was much higher than any other peroxidase activity. Syringaldazine utilization by peroxidase has been suggested to be the major activity during lignification (Peyrano *et al.* 1996). Our results indicated that this activity was predominant in jute bark of the selected age. Our results further indicated that activity with NADH was very low in bark. It has been suggested that lignification by peroxidase requires H₂O₂ as co-substrate and may be formed in situ by peroxidase acting as NADH oxidases (Grass *et al.* 1977, Polle and Chakrabarti, 1994). Our finding seem to indicate that either the activity was sufficient for the purpose of lignification or that the H₂O₂ was obtained from secondary sources such as oxidases. The enzyme band pattern did not differ between plant to plant on PAGE. Only the major band was obtained from all the selected plants (Figures 1&2). The difference that emerged was at the level of band intensity. This suggested a difference at the level of control of a single gene rather than in the expression of different peroxidase genes.

ACKNOWLEDGMENT

We are grateful to NATP (ICAR) for financial assistance.

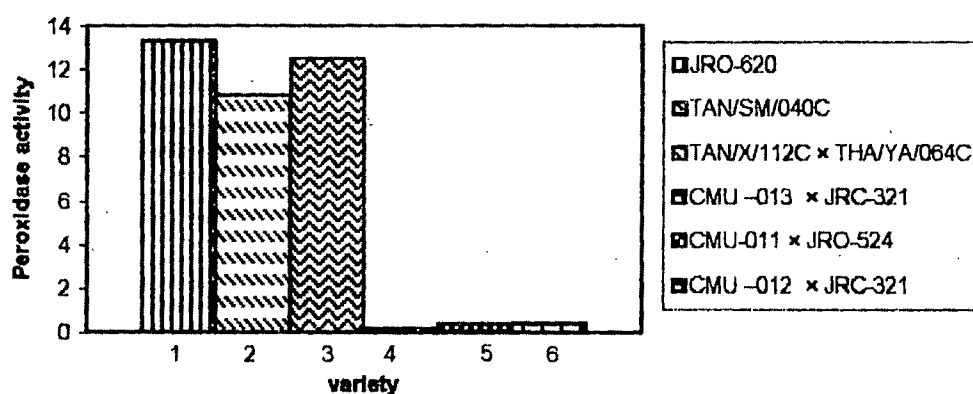


Fig. 1(a). Peroxidase content in different jute varieties

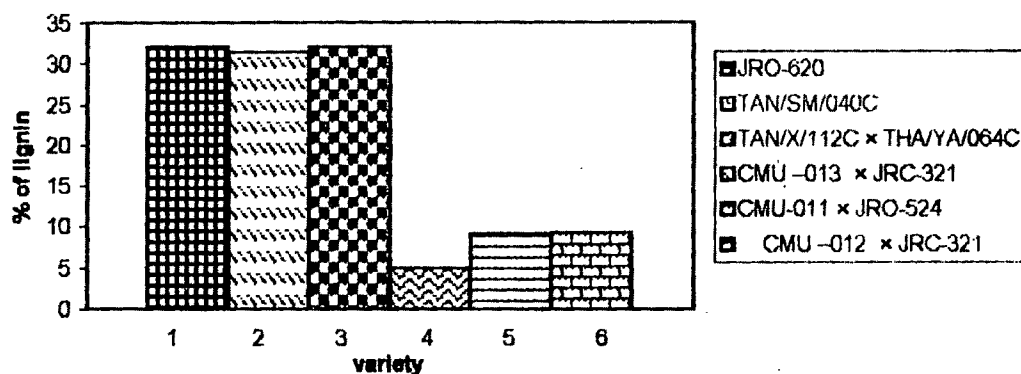


Fig. 1(b). Lignin content in different jute varieties

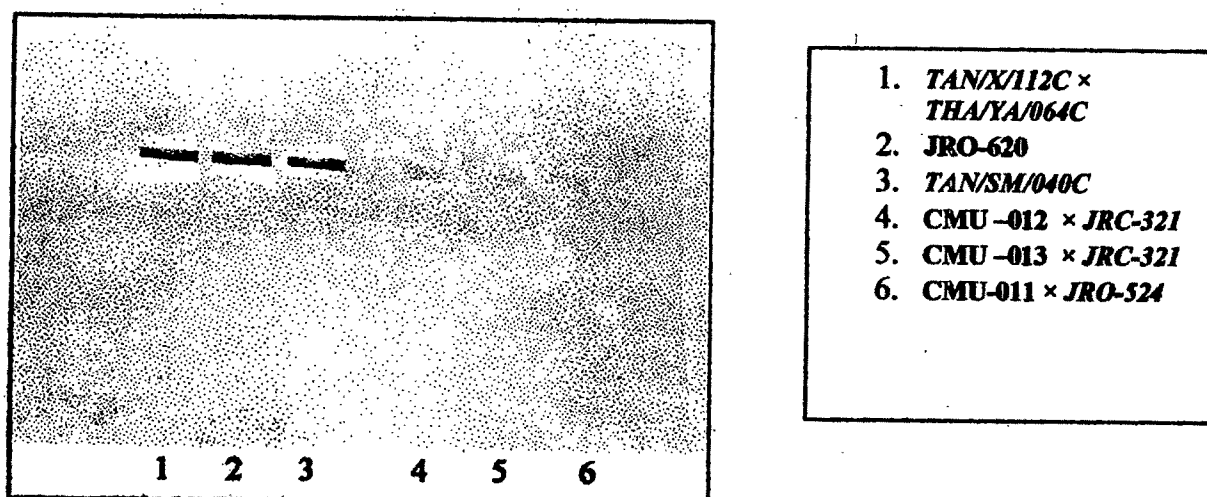


Fig. 2. PAGE pattern of peroxidase in jute bark

REFERENCES

- Biles, C. and Ables, A.f. 1982. *Plant Physiol.*, **70** : 1128-31.
- Chakrabarti, K. Pal, s.K., Goswami, A., Das, F. 2002. *Recent Eucalypt Research in India.*, 116-118.
- Chen, G.X. and Asada, K. 1989. *Plant cell physiol.*, **30** : 987-988.
- Cowles, J.r., Le May, R., Jahns, g., Scheld, w.H. and Peterson, C. 1989. *American Chemical Society*, 203-211.
- Das, F., Paul, S.K. and Chakrabarti, K. 1999. *Indian Biologist*, **31**(1) : 67-90.
- Evans, J.J. and Himmetsbah, D.J. 1991. *J. Agric. Food Chem.*, **39** : 830-832.
- Gross, G.G., Janse, C., Elstner, and E.F. 1977. *Planta.*, **136** : 271-276.
- Imberty, A., Goldberg, R. and Catesson, A.M. 1985. *Planata.*, **164** : 221-226.
- Ishida, A.K., Okubo. and K. Oneo. 1987. *Plant cell Physiol.*, **28** : 723-726.
- Klason. 1995. TAPPI Test method T222 : 88.
- Lagrimini, L.M. 1991. *Plant Physiol.*, **96** : 577-583.
- Lewis, N.G. and Yamamoto, E. 1990. *Annu. Rev. Plant. Physiol. Plant Mol. Biol.*, **41** : 455-496.
- Mader, M., Amberg - Fischer, V. 1982. *Plant Physiol.*, **70** : 1132-1134.
- Mittal, R. and Dubey, R.S. 1991. *Plant Physiol. Biochem.*, **29** : 31-40.
- Pedreno, M., Rosebarcelo, A., Sabater and Munoz, R. 1989. *Plant Cell Physiol.*, **30** : 237-241.
- Peyrano, G.M., Forchetti, S.M., tigier, H., Talei Snik, E. 1996. *Biotech Histochem.*, **71** (5) : 258-262.
- Pole, A., Otter, T. and Seifert, F. 1994. *Plant Physiol.*, **106**, 53-60.

EFFECT OF VERMICOMPOST AND FERTILITY LEVELS ON GROWTH, YIELD AND YIELD ATTRIBUTES OF MALT BARLEY (*HORDEUM VULGARE* L.)

D.K. ROY, B.P. SINGH AND PARAMJIT SINGH

Department of Agronomy, CCS HAU, Hisar-125004

ABSTRACT

Field experiments were conducted during 1998-99 and 1999-2000 at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar to find out the integrated nutrient management for malt barley. The results revealed that application of 10 t ha⁻¹ vermicompost significantly increased the plant height, number of tillers and dry matter production per meter row length over control. All the growth parameters attained their maximum value at 10 t ha⁻¹ vermicompost. Highest number of productive tillers, panicle length, panicle weight, filled grains and test weight were recorded with 10 t ha⁻¹ vermicompost. There was a significant rise in grain and straw yield of malt barley with the application of 10 t ha⁻¹ vermicompost. Application of vermicompost increased the harvest index non-significantly during both the years of experimentation. N₉₀P₃₀ levels of fertility also followed the similar trend of growth, yield and yield attributes of malt barley as that of 10 t ha⁻¹ vermicompost over rest of the treatments during 1998-99 and 1999-2000.

Key words : Malt barley, fertility levels, vermicompost.

Barley is the most important food, feed and industrial crop of the world and the oldest cereal on the earth. At global level, its productivity is 2.28 t ha⁻¹, while in India its productivity is 1.89 t ha⁻¹. The productivity of barley in Haryana is 2.8 t ha⁻¹. After the liberalized licensing policy, many new breweries are coming up and the share of barley in the production of malt for manufacture of beer is gradually rising. In India during three decades, intensive agriculture involving exhaustive high yielding varieties of cereals has led to heavy withdrawals of nutrients from the soil. It is estimated that annually 25.1 m tonnes of nutrients (N, P, K) are removed from the soil whereas, only 17.5 m tonnes are supplied from soil source including organics. The fertilizer production in our country is less than the required amount. To fill this gap, alternate source of nutrients have to be looked for. Organic wastes and biofertilizers are the alternate sources to meet the nutrient requirement of the crops and to bridge the gap. Use of vermicompost is being advocated for sustainable fertility management as a part of nutrient supply in various field crops. In vermicomposting, beneficial soil bacteria alongwith earthworms are involved as the prime work force to process the

organic waste. These are 10 times faster in their work compared to bacteria and fungi associated with the process of composting (Venkataratnam, 1996).

MATERIALS AND METHODS

A field experiment was conducted at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar in rabi season during 1998-99 and 1999-2000. The soil was sandy loam in texture. It was slightly alkaline with pH 7.9. The soil experimental plot was low in organic carbon (0.36%) and available nitrogen (147.50 kg ha⁻¹) and high in available potash (380.70 kg ha⁻¹). The layout was a factorial combination of vermicompost at 0 and 10 t ha⁻¹ and fertility levels F₀ (N₀P₀), F₁ (N₃₀P₃₀), F₂ (N₆₀P₃₀) and F₃ (N₉₀P₃₀) in kg ha⁻¹. These were replicated in three blocks. The treatment dose of nitrogen was split applied; half at sowing alongwith the treatment dose of phosphorus and half of nitrogen was top dressed at first irrigation i.e. 35 DAS. The variety used was BH-393. Well decomposed vermicompost was applied uniformly as per treatment and immediately incorporated into the soil by ploughing field with disc harrow one month before sowing.

Table 1. Effect of vermicompost and fertility levels on growth and yield attributes of malt barley

[illegible]

Table 2. Effect of vermicompost and fertility levels on grain and straw yield (t ha^{-1}) and harvest index of malt barley

Treatments	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Pooled grain yield (t ha^{-1})		Harvest index	
	1998-99	1999-2000	1998-99	1999-2000	1998-99	1999-2000	1998-99	1999-2000
Vermicompost (t ha^{-1})								
0	4.02	3.95	5.38	5.55	3.99	42.93	42.03	
10	4.43	4.48	5.98	6.15	4.46	42.62	42.23	
S.E.m $\pm$	0.07	0.08	0.07	0.05	0.06	0.45	0.44	
C.D. ($P=0.05$)	0.22	0.23	0.22	0.15	0.18	NS	NS	
Fertility levels (kg ha^{-1})								
N_0P_0	2.90	3.05	3.75	3.85	2.98	43.6	43.31	
$\text{N}_{30}\text{P}_{30}$	3.95	3.95	5.25	5.45	3.95	43.0	42.02	
$\text{N}_{60}\text{P}_{30}$	4.75	4.65	6.45	6.65	4.70	42.4	41.14	
$\text{N}_{90}\text{P}_{30}$	5.28	5.20	7.25	7.45	5.24	42.2	41.05	
S.E.m $\pm$	0.10	0.11	0.10	0.07	0.09	0.76	0.76	
C.D. ($P=0.05$)	0.31	0.32	0.31	0.21	0.28	NS	NS	

RESULTS AND DISCUSSION

The application of F_3 (90 kg N + 30 kg P_2O_5 ha⁻¹) level of fertility resulted into excellent growth as evidenced by taller plants, higher number of tillers per meter row length in comparison to lower levels of fertility (Table 1). Application of phosphorus increased the dry matter accumulation (Likun *et al.*, (1995). Nitrogen application increased plant height (Roy and Singh, 1989; Prokhorov *et al.*, 1998) and tillering (Birch and Long, 1990), which ultimately lead to higher dry matter production (Birch and Long, 1990). Effect on growth attributes was well pronounced with the application of 10 t ha⁻¹ vermicompost. Increase in plant height, number of tillers and dry matter production due to vermicompost application was supported by the findings of Jadhav *et al.*, (1997).

Significant increase in yield attributes of barley with nitrogen application have also been reported by Allam (1997), Subhash *et al.*, (1998) and Singh *et al.* (1998). All yield attributes i.e. number of ear bearing tillers per meter row length, panicle length, member of grains per spike and 1000-grain weight were significantly improved with fertility levels. The similar findings of beneficial effect of phosphorus on the yield attributing characters have also been reported by Prasad and Joshi (1988) and Malik *et al.* (1995).

With each successive increase in fertility level, there was a significant increase in grain yield of malt barley during both the years. The maximum percent increase in grain yield with $N_{90}P_{30}$ fertility level over control was recorded

as 82.07 and 70.49 per cent during both the years respectively. The percent increase in grain yield with F_1 ($N_{30}P_{30}$) and F_2 ($N_{60}P_{30}$) levels of fertility over control was 36.20, 29.51 and 63.79, 52.45 per cent during 1998-99 and 1999-2000, respectively. Significant increase in grain and straw yields of barley with level of fertility might be on account of higher dry matter production, higher number of tillers per meter row length, improved yield attributing characters and due to balance nutrition of crop plant which finally improved the grain and straw yields over lower levels of fertility. These results were in line with the earlier findings of Carter (1993) and McKenzie (1998).

Highest number of productive tillers, panicle length, filled grains and test weight were recorded with 10 t ha⁻¹ vermicompost. This was due to higher productive tillers and panicle length with microbial stimulation effect of vermicompost and N supplied through gradual mineralization in addition to the inorganic fertilizer, which provided enough nutrients during the growth period in steady manner.

The percent increase in grain yield with t ha⁻¹ vermicompost over control was recorded as 10.2 and 13.42 per cent during 1998-99 and 1999-2000, respectively. Increased supply of N through vermicompost resulted in greater absorption and utilization, which resulted in better growth of barley having direct bearing on the yield attributes as well as the grain yield. The beneficial effect of vermicompost on yield parameters was reported by Ismail (1995) and Devi Dayal and Agarwal (1998).

REFERENCES

- Allam, A.Y. 1997. Response of some barley cultivars to nitrogen fertilization in sandy calcareous soil. *Assiut Journal of Agricultural Sciences*, 28(1) : 89-98.
- Birch, C.J. and Long, K.E. 1990. Effect of nitrogen on the growth, yield and grain protein content of barley. *Australian J. Exptl. Agric.*, 30(2) : 237-242.
- Carter, M.R. 1993. Response of barley to nitrogen under moisture scarce condition. *Indian J. Agron.*, 38 (3) : 392-395.
- Devi Dayal, and Agarwal, S.K. 1998. Response of sunflower (*Helianthus annuus*) to organic manures and fertilizers. *Indian J. Agron.*, 43 (3) : 469-473.
- Ismail, S. 1995. Earthworms in soil fertility management in organic agriculture. pp. 90-92.
- Jadhav, A.D.; Talashikar, S.C. and Power, P.G. 1997. Influence of the conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice *J. Maharashtra agric. Univ.*, 22(2) : 249-250.

- Likun Cao Yi Ping and Su Dechun 1995. Available Olsen P in the soil profile and the response to deep layer phosphorus application. *Acta Agricultural Universitatis Pekinensis*, 21 : 84-88.
- Malik, A.; Sahi, F. and Abbasi, K. 1995. One influence of phosphorus on the components of yield of irrigated wheat in Pakistan. *J. Agric. Soc. Univ. Wales*, 75 : 41-49.
- McKenzie, R.H. Middleton, A.; Solberg, E.; Dimulder, J. and Najda, H. 1998. Nitrogen and phosphorus optimize barleysilage production. *Better Crops with Plant Food*, 82 (4) : 22-23.
- Prasad, L.C. and Joshi, A.K. 1988. High yielding huskless barleys for lands of low fertility. *Indian Fng.*, 40 (12) : 11.
- Prokhorov, V.N.; Laman, N.A. and Pulyrskii, I.N. 1998. Features of nitrogen exchange in crop of spring barley differing in productivity. *Vesti Akademii Nauk Belarusi. Seriya Bivalagichnykh Nauk*, 33 : 22-32.
- Roy, R.K. and Singh, B.K. 1989. Response of hull-less barley to fertility application under rainfed situation of diara land. *Indian J. Agron.*, 34(4) : 480-482.
- Singh, K.P.; Singh, H.; Ranwa, R.S.; Kathuria, M.K. and Singh, S.M. 1998. Relative efficacy of vermicompost and some other organic manures integrated with chemical fertilizers in cereal based cropping systems. *Haryana J. Agron.*, 14(1) : 34-40.
- Subhash Chandra; Jat, N.L. and Singh, Ravindra 1998. Yield attributes of barley as influenced by nitrogen, zinc sulphate and their correlation and regression with yield. *Crop Research (Hisar)*, 15(1) : 123-124.
- Venkataratnam, L. 1996. Vermicompost is a profitable new agri-business in organic farming. Food Security in Harmony with Nature. 3th IFOAMASIA Scientific conference and General Assembly, 59.

EFFECT OF INSECTICIDES ON NITRIFYING BACTERIA IN SOIL

LATA, A.K. PANDEY AND K.P. NARAYAN

Division of Microbiology
Indian Agricultural Research Institute, New Delhi - 110 012

ABSTRACT

Effect of quinalphos, an organophosphate, a chlorinated insecticide (Benzene Hexachloride) and a carbamate (Carbofuran) insecticide was studied on soil nitrifying bacteria (*Nitrobacter* and *Nitrosomonas*) at three doses (recommended dose, below and above recommended dose). Quinalphos had an adverse effect on *Nitrosomonas* population but stimulated *Nitrobacter* population at low concentration (0.25 kg. a.i. ha⁻¹). Benzene Hexa Chloride did not have any effect on the nitrifying bacteria. Carbofuran exhibited an initial adverse effect on *Nitrosomonas* population at all the concentration tested but it had no effect on *Nitrobacter*.

Key words : Insecticides, nitrifying bacteria, *Nitrobacter*, *Nitrosomonas*.

Nitrifying bacteria have a major role in the N-cycle and play important role in soil fertility. Plants readily assimilate nitrate, therefore nitrification has been used as an index for soil fertility (Paul and Clark, 1989). Continuous and widespread use of pesticides/insecticides has resulted in adverse influence on biological system (Edwards, 1972). Among the biochemical processes in the soil, nitrification is probably the most sensitive to pesticides. Because of the persistence of chlorinated insecticides in the environment, the organophosphate and Carbamates insecticides are being used to control insects and pests. Keeping in view the above facts, the present investigation was undertaken to study the effect of organophosphate (quinalphos ; 0,0-diethyl-0-quinoxalyl-2-phosphorothionate), carbamate (carbofuran; 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate) and chlorinated hydrocarbon (Benzene hexa chloride) on nitrifying bacteria-*Nitrosomonas* & *Nitrobacter*.

MATERIALS AND METHODS

The experiment was carried out in pots and the soil used was silty clay loam (pH 7.2). Three insecticides :- Chlorinated insecticide (B.H.C), Organophosphate (Quinalphos), and Carbamate (Carbofuran) were applied in three doses

(recommended dose, below and above recommended dose) at following rates : Quinalphos 25 EC, purchased from Sandoz (India) Ltd. was applied at 0.25, 0.50, 1.0 kg. a.i. ha⁻¹, Benzene hexa chloride 10% dust obtained from Hindustan Insecticide Ltd., India and Carbofuran granule 3G; from Rallis India Ltd. was applied at 0.50, 1.0 & 2.0 kg. a.i. ha⁻¹, Nitrogen, at a concentration of 200 ppm, was supplied in soil through ammonium sulphate to stimulate population of nitrifying bacteria at 0 day.

The experiment was set up in triplicate and the pots were incubated at room temperature (min. 22°C; max. 33°C). Sterilized distilled water was added from time to time so as to maintain the water holding capacity of soil near about 50%. Soil samples were collected from three places and mixed homogenously. The samples of all the three pots of one treatment were mixed homogenously and pooled samples were considered as one sample of that particular treatment. Population of nitrifying bacteria (*Nitrosomonas* and *Nitrobacter*) was determined by MPN method (Black, 1965) at the sampling interval of 0, 4th, 8th & 16th days. At zero day, samples were pooled from all the treatment pots and used for population determination.

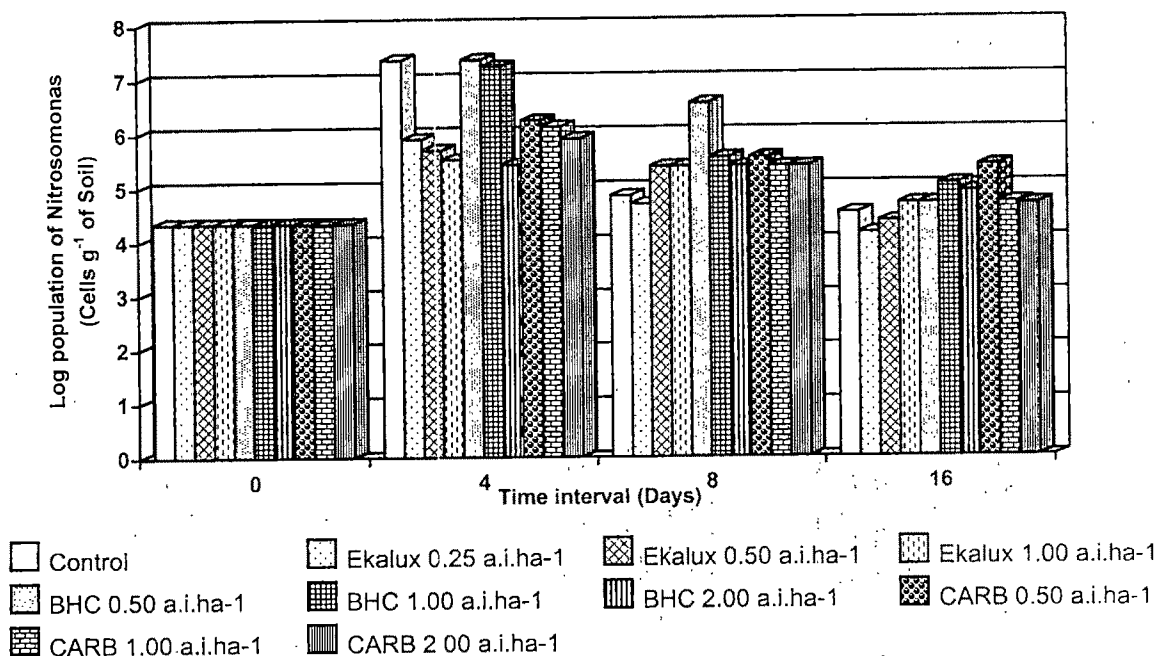


Fig. 1. Effect of insecticides on population of *Nitrosomonas* at different time interval

RESULTS AND DISCUSSION

The effect of insecticides on the population of nitrifying bacteria (*Nitrosomonas* & *Nitrobacter*) was observed at three different concentrations of each insecticide at various time intervals following most probable number method.

In all the treatments, including control, there was an increase in *Nitrosomonas* population at 4th day as compared to zero day. This might be due to the stimulatory effect of ammonium sulfate which was added to soil at zero day. Alexander (1977) reported that application of ammonium salt improves the population of *Nitrosomonas* & *Nitrobacter*. However when compared with control, the population of *Nitrosomonas* exhibited an inhibition in all treatment. Quinalphos showed maximum adverse effect on *Nitrosomonas* population. The population of *Nitrosomonas* exhibited decline on 8th and 16th day in all the treatments including control. However it is interesting to note that BHC at 0.50 kg. a.i. ha⁻¹, had a stimulatory effect on *Nitrosomonas* population on 8th day of incubation (Fig.1).

This is an accordance with results reported by Lin et al., (1972), Ross (1974), Tu (1970), Elliott et al., (1972) that organophosphorus insecticide

are inhibitory to nitrification and adversely effect the change of $\text{NH}_4^+\text{-N}$ to $\text{NO}_2\text{-N}$. Patel and Desai (1985) reported that normal field rate of insecticide did not affect nitrification and ammonification but 1.0 & 100 lt. a.i. ha⁻¹ markedly reduced the process.

The population of *Nitrobacter* was considerably less than *Nitrosomonas* in soil (Fig. 2). This could probably be explained on the basis that nitrate might have accumulated under certain circumstances. (Alexander, 1977). The population of *Nitrobacter* in control increased from zero day to 8th day with the maximum of 7.9×10^4 cells/gm. of soil. Quinalphos at 0.25 kg. a.i. ha⁻¹ exhibited stimulatory effect in later stages, which resulted in higher population of *Nitrobacter* on 16th day registering about 3 fold increase over control. Quinalphos at 0.5 kg. a.i. ha⁻¹ had no effect on *Nitrobacter* population. However at higher concentration (1.0 kg. a.i. ha⁻¹) of quinalphos, there was decrease in *Nitrobacter* population on 16th day. BHC, at all concentrations, didn't have any effect on *Nitrobacter* population. Carbofuran at lower dose (0.5 kg. a.i. ha⁻¹), was stimulatory for *Nitrobacter* population. At 16th day the stimulation was better with carbofuran as compared to quinalphos. Higher dose of carbofuran did not

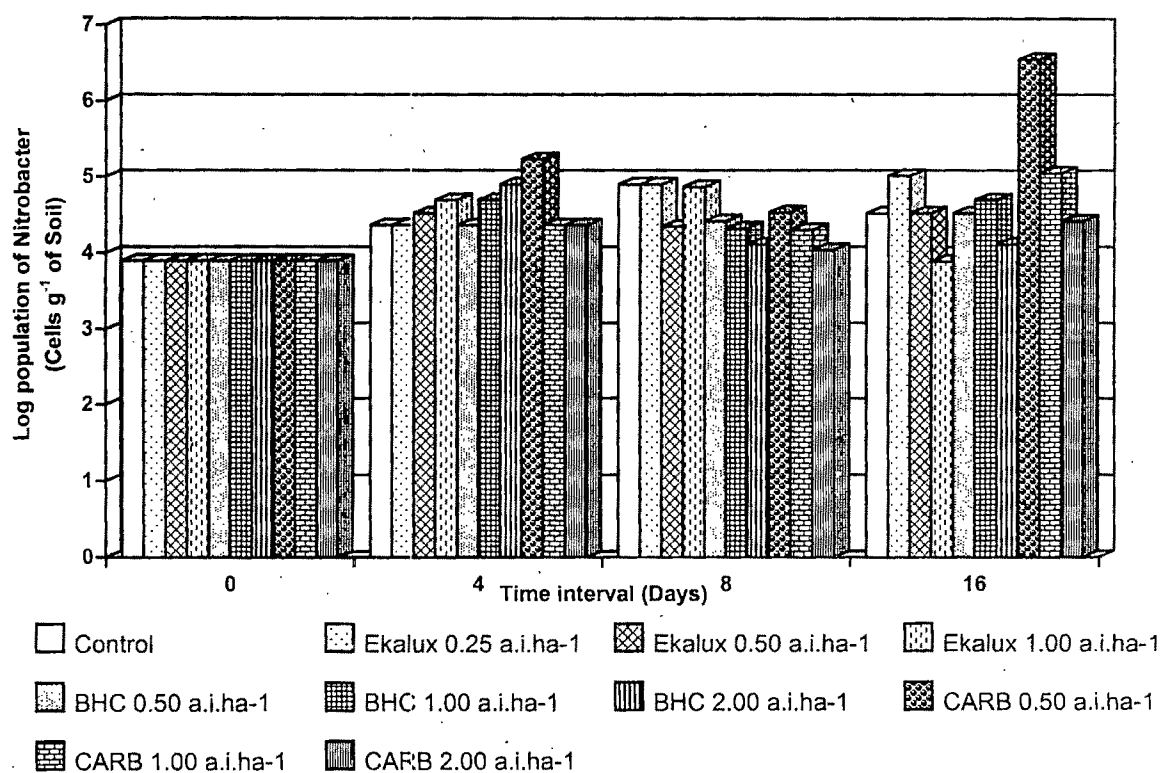


Fig. 2. Effect of insecticides on population of *Nitrobacter* at different time interval

have any adverse effect on *Nitrobacter* population. These findings are in agreement with earlier reports of Tu (1970); Lin *et al.*, (1972) and Joseph (1974) who reported that normal field rate of organophosphate, carbamate and organochlorine insecticides did not affect Nitrification in general and *Nitrobacter* in particular. Ramakrishna *et al.* (1978) also demonstrated that Carbofuran at lower concentration stimulated *Nitrobacter* population.

The results of present investigation indicated that there was no significant influence of all three classes of insecticide on soil nitrifying bacteria, if applied at recommended doses. However deleterious effects may be exerted on soil microflora if higher doses are applied. Therefore it is safe to use recommended doses of insecticides as it does not affect soil microflora adversely.

REFERENCES

- Alexander, M. 1977. Introduction to Soil Microbiology. John Wiley & Sons Inc., New York. pp. 256-261.
- Black, C.A. 1965. Methods of Soil Analysis, Part 2. American Society of Agronomy. Inc. Madison and Wisconsin, USA. pp. 1213-1483.
- Edwards, C.A. 1972. Insecticides, in Organic Chemicals in the Soil environment, Vol. 2 (Edts. Goring C.A.I. and Hamaker J.W.) Marcel Dekker, New York, pp 513-568.
- Elliot, J.M., Marks, C.F. and Tu, C.M. 1972. *Can. J. Plant Sci.*, 52: 1-11.
- Lin, S.H., Funke, B.R. and Schultz, J.T. 1972. *Plant and Soil.*, 37: 489-496.
- Patel, B.V. and Desai, S.G. 1985. *Indian J. Microbiol.*, 25: 26-28.
- Paul, E.A. and Clark, F.E. 1989. Soil Microbiology and Biochemistry, Academic Press, New York. pp. 133-148.
- Ramakrishna, C., Rao, V.R. and Sethunathan, N. 1978. *Soil Biol. Biochem.*, 10: 555-556.
- Ross, D.J. 1974. *N.Z.J. Agr. Res.*, 17: 9-17.
- Tu, C.M. 1970. *Applied Microbiol.*, 19: 479-484.

RELATIVE PERFORMANCE OF SODICITY TOLERANT RICE VARIETIES ON (*CHLORIS GAYANA*) BASED LAYS UNDER DIFFERENT DOSES OF NITROGEN

BANWARI LAL AND MANJU SUMAN

Indian Grassland, Fodder and Agroforestry Research Institute, Jhansi - 284 003

ABSTRACT

Relative performance of four HYV of rice (CSR-13, Sita Jaya and USAR-1) two native (Bejhari, Kalmuhi) were evaluated during 1997 and 1998 in relation to varying levels of N application under alkali soil. The treatments comprised *Chloris gayana* in main plots on 4.5 m tractor spacing as lay. CSR-13 produced significantly higher grain yield in comparison to other HYV. Further, the yield level of Sita and Bejhari was at par in first year of cultivation. However, in second year of investigation the general yield of rice varieties out yielded 3 to 5% grain as well as straw over previous years. The application of nitrogen up to 120 kg ha⁻¹ significantly increased the grain yield, panicle m⁻², grain panicle⁻¹, test weight. These yield parameter were increased due to higher doses of nitrogen and yield attributing character viz., plant height, number of tillers plant⁻¹, LAI. Maximum survival of tussocks of *Chloris gayana* was observed in second year of experimentation and significantly increased with each successive dose of nitrogen application over control. However, non-significant difference was observed among different doses of N application i.e. 30 to 120 kg ha⁻¹.

Key words : Rice, sodic soils, nitrogen levels, rabi forages.

India with largest rice growing area in the world, often experiences constraints of problem soils for rice cultivation. Salinity and sodicity in the crop root zone are cause of severe damage of establishment as well as productivity. A number of field experiments led to the conclusion that rice is one of the alternatives for reclamation of salt-affected soils. However, which variety have to be adopted by the farmers is a great cure city and enthusiasm for twin objectives i.e. production of rice and amelioration of salt-affected soils. As such about 95 m ha area of the earth surface is affected due to salt problem in the root zone of crops (Ghassemi, et al. 1995). The salt-affected soils are spread over 8.4 m. ha. (4% of the total cultivated area) in India. Since these soils are highly variable in nature as per aridity and rainfall. Therefore, different types of techniques are required for their reclamation. The placement of excess exchangeable sodium from such soils can be made by gypsum (Ca₂SO₄). The requirement of gypsum on heavy and medium soils is more in comparison to lightly soils (Abrol, 1973). As such these soils are poor in fertility as they require 20-25% more

nitrogenous and Zn fertilizers than the normal soils (Yadav, 1980). In general integration of biological amelioration of salt affected soils with chemical and mechanical measures has been found more useful in comparison to any single method. Therefore, growing of crops and cropping systems that tolerant to the excess to exchangeable sodium may ensure reasonable return during the initial phase of reclamation. On such soils the crops that are able to withstand excess moisture conditions are also more tolerant to sodic conditions (Lal, 1997). Since the farmers in tropical areas of India as well as other parts of the world are not familiar with improved fodder production technologies due to various reasons. Moreover, these areas are highly fertile but less productive because of serious limitation imposed by high concentration of slats in the crop root zone. Further, the farmers are forced to apply higher doses of fertilizers to boost the grain as well as straw productivity. However, lot of nitrogen is lost in the rice cultivation. Thus quantification of economical optimum dose is of prime importance for saving the energy input in rice on such salt-affected problem soils.

MATERIALS AND METHODS

The field experiment was conducted during 1997-98 to 1999-2000 at UPLDC Farm, Shivery Lucknow (26.5°N latitude, 80.5°E longitude and 120 m above man sea - level). The attractants comprised *Chloris gayana* in main plots on 4.5 m tractor spacing with six varieties of rice (four HYV i.e. CSR-13, Sita, Jaya and USAR-1) and tow native (bejhari, Kalmuhi) in main plots, while four doses of nitrogen (30, 60, 90 and 120 kg ha⁻¹) with control in sub-plots were tried in split-plot design with 4 replications. The soil of the experimental plot was loam (sand 52.5%, silt 28% and clay 19/5%) in texture with field capacity 20% (w/w) wilting point 8.5% (w/w) and bulk density 1.45 g cm⁻¹. The other initial soil properties of the sodic soil where experiment was initiated and detailed profile characteristics are presented in Table 1. The soil was sodic in reaction with pH 10.6 with organic matter 0.18%, cation exchange capacity 11.5 C mol (p+) kg ha⁻¹, E.C. 3.0 dsm⁻¹, ESP 68-89, CaCO₃ 2.41% and Available P 19.5 and K 388 kg ha⁻¹. To prevent the field from weeds, butachlor @ 2 kg a.i. ha⁻¹ as pre-transplanting was applied followed by hand weeding at 20 days after transplanting. A uniform dose of 5 t ha⁻¹ gypsum was applied in the month of June to flush the salts (Na₂SO₄) from crop root zone with the help of continuous standing water for 10 days. The saplings of *Chloris gayana* forage grass were transplanted on July 18, 1997 on 2.5 m row apart and 50 m plant to plant in the rows forage grass was harvested four times in the months of October, November, February and March in both the years of investigation i.e. 1997-98 and 1998-99. The saplings of rice varieties were transplanted in between the rows of grass in the same season. Soil chemical analysis was done by means of Jackson (1967). Half of nitrogen along with full dose of phosphorus and potash were applied as basal while remaining dose of nitrogen was top dressed after 25 days of transplantation. Cultural operations were performed as and when required and different physiological growth parameters were recorded during crop growth period.

RESULTS AND DISCUSSION

Effect of varieties

Data presented in Table 1 indicated that CSR-13 produced significantly higher grain yield in comparison to other HYV. Further, the yield level of sita and bejhari was at par in first year of cultivation. However, in second year of investigation the general yield of rice varieties out yielded 3 to 5% grain as well as straw (Table 1). The lowest yield 2.86 t ha⁻¹ in 1997 and 2.96 t ha⁻¹ in 1998 was observed in kalmuhi (local variety). This was due to less number of panicle m⁻², grains panicle⁻¹, and test weight. While maximum straw yield 6.32 t ha⁻¹ in 1997 and 6.55 t ha⁻¹ in 1998 was observed in Bejhari which was at par with USAR-1 and significantly higher over other varieties (Table 1). In straw yield kalmuhi and CSR-13 were at par. Thus CSR-13, sita and jaya (HYV) were at par in harvest index in both the years of investigation and significantly superior over USAR-1, kalmuhi and bejhari (Table 1). This might be due to more number of panicle m⁻², more plant height, less test wt. less grains panicle⁻¹, less LAI (Table 2). Although the cultivated varieties used in the test were at par in protein content in grains as well as straw. However, maximum protein was observed in sita in both the years of investigation that followed by CSR-13 and jaya. The significant increase in grain yield was also supported due to panicle bearing tillers, grain ear head and test weight by Salan and Subramanian, (1988) and (Pandey, et al. 2000).

Effect of nitrogen

The application of nitrogen up to 120 kg ha⁻¹ significantly increased the grain yield, panicle m⁻², grain panicle⁻¹, test weight. These yield parameter were increased due to higher doses of nitrogen and yield attributing characters viz. plant height, number of tillers plant⁻¹, LAI. This indicated that nitrogen application increase DN supply to plant increased concentration and above ground biomass and finally the up take. The economical optimum dose of nitrogen worked out to the level of 105 kg ha⁻¹ (Fig. 1). The findings are in agreement with the results reported by Salam and Subramanian, (1988), Ram Andrao, (1995) and Pandey, et al. (2000) also

Table 1. Effect of nitrogen doses on yield parameters of different rice cultivars and forage grasses

Treatments	Panicle m ²	Grains panicle ⁻¹		1000 grain wt. (g)		Grain yield (t ha ⁻¹)		Straw yield (t ha ⁻¹)		Harvest index (%)	
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
N levels (kg ha ⁻¹)											
0	220	228	59	18.0	18.2	2.16	2.24	3.78	3.88	36.36	36.60
30	285	292	70	19.0	20.1	2.56	2.65	4.42	4.56	36.49	36.75
60	315	326	76	22.0	23.0	3.08	3.20	5.17	5.52	37.33	36.69
90	332	335	80	24.7	25.0	3.57	3.70	6.17	6.40	36.65	36.63
120	344	346	85	26.0	26.5	3.86	3.98	6.67	6.82	36.65	36.85
C.D. at 5%	18.2	18.7	5.1	1.5	1.6	0.30	0.32	0.11	0.13	NS	NS
Cultivars											
CSR-13	275	278	69	22	23	4.10	4.32	5.12	5.258	44.40	45.14
Sita	290	293	74	24	25	3.22	3.24	4.10	4.26	43.90	43.20
Jaya	287	289	75	27	27	2.87	3.15	3.83	4.15	42.60	43.15
USAR-1	295	296	77	23	23	2.98	3.12	6.26	6.42	32.25	32.70
Kalmuhi	267	272	72	22	22	2.86	2.96	5.68	5.81	33.48	33.75
Bejhari	272	275	75	21	22	3.19	3.30	6.32	6.55	33.54	33.50
C.D. at 5%	19.5	20.2	5.2	1.7	1.8	0.19	0.21	0.17	0.18	2.15	2.21

Table 2. Effect of nitrogen doses on growth parameters of different rice cultivars

Treatments	Plant height (cm)		No. of tillers plant ⁻¹		LAI		Protein Grain		Protein (%) straw	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
N levels (kg ha⁻¹)										
0	94.80	95.88	3.60	3.96	2.86	2.89	8.2	8.3	6.2	6.3
30	96.60	100.46	4.00	4.80	3.12	3.11	8.4	8.4	6.4	6.4
60	104.80	106.64	5.40	6.30	3.25	3.29	8.4	8.7	6.8	6.9
90	110.80	112.44	6.60	7.58	3.76	3.78	8.9	8.8	7.0	7.1
120	117.20	119.02	8.20	9.22	4.16	4.22	9.0	9.2	7.2	7.3
C.D. at 5%	2.36	2.38	0.60	0.66	0.51	0.54	NS	NS	NS	NS
Cultivars										
CSR-13	98.00	101.00	4.6	5.1	4.0	4.2	8.6	8.6	6.3	6.4
Sita	86.00	87.90	5.8	7.2	4.5	4.7	8.7	8.7	6.2	6.1
Jaya	82.20	83.60	6.4	7.4	4.1	4.2	8.4	8.5	6.0	6.2
USAR-1	110.60	112.30	5.4	6.2	4.0	4.1	8.6	8.6	6.5	6.6
Kalnuhi	121.20	122.00	5.0	5.6	3.2	3.6	8.4	8.5	6.4	6.5
Bejhari	125.08	128.10	4.8	5.5	3.8	3.9	8.3	8.4	6.3	6.4
C.D. at 5%	1.45	1.47	0.62	0.65	0.53	0.54	NS	NS	NS	NS

Table 3. Performance of *Chloris gayana* on tractor spacing in rice cultivars and different levels of nitrogen

Treatments	Survival (%)		Biomass (t ha ⁻¹)		Dry		pH (1:2.5)	
	1999	2000	1999	2000	1999	2000	1999	2000
N levels kg/ha								
0	79	83	21.2	23.5	4.8	4.9	9.8	9.6
30	82	85	25.5	26.7	5.0	5.1	9.2	9.5
60	84	86	27.2	28.5	5.1	5.2	9.7	9.5
90	87	88	29.4	30.2	5.2	5.4	9.7	9.4
120	88	92	30.2	30.8	5.8	6.5	9.6	9.4
CD at 5%	9	11	2.8	2.6	0.43	0.47	0.02	0.02
Cultivars								
CSR-13	82	83	25.5	25.8	4.9	5.2	10.2	10.1
Sita	83	84	26.2	27.5	5.1	5.3	10.1	10.1
Jaya	85	85	24.1	25.3	4.3	5.1	10.2	10.1
USAR-1	83	85	24.5	25.6	4.8	5.2	10.1	10.0
Kalmuhi	82	84	26.9	27.5	5.3	5.9	10.20	10.1
Bejhari	82	85	27.8	28.0	6.0	6.9	10.20	10.0
CD at 5%	NS	NS	3.4	3.2	0.39	0.34	NS	NS

observed the optimum N level of 71 to 116 kg ha⁻¹ for early to medium duration rice varieties.

Effect of Forage grass on rice and vice-versa

Maximum survival of tussocks of *Chloris gayana* was observed in second year of experimentation and significantly increased with each successive dose of nitrogen application over control. However, non-significant difference was observed among different doses of N application (Table 3). Similar trend in the productivity of *Chloris gayana* was observed in green as well as dry biomass production in terms of fodder value. The pH of upper soil layer (0-15 cm) gradually decreased with each successive higher dose of nitrogen in rice that also facilitate the soil improvement (Table 3). The survival of *Chloris gayana* as well as pH value of upper soils layer (0.15 cm) could not be influenced by any of the rice varieties. However maximum green as well as dry biomass production of *Chloris gayana* was observed in between Bejhari in both the years of investigation that followed by kalmuhi and Sita. The other varieties were at par in terms of interaction with *chloris gayana* (Table 3).

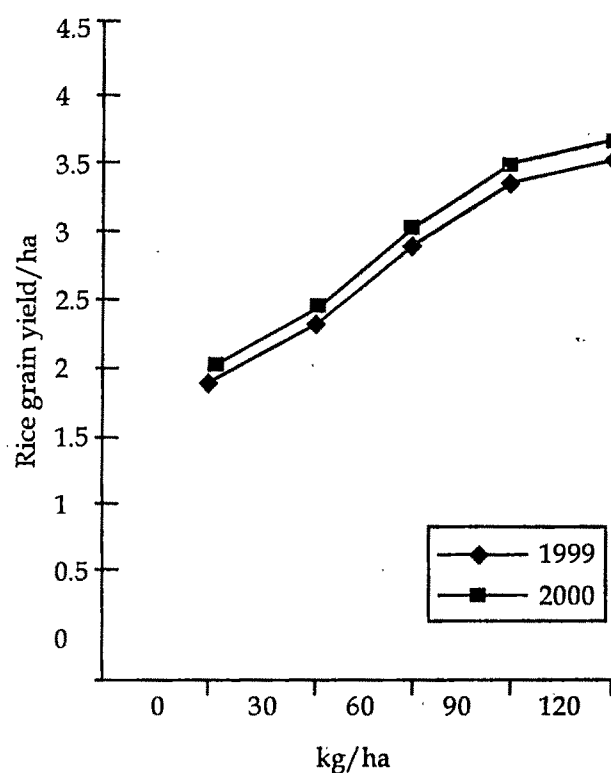


Fig. 1. Effect of N levels on rice cultivars

REFERENCES

- Abrol, I.P., Dhaliya, I.S. and Bhupal, D.R. 1973. *Soil Sci.*, **120** : 30-36.
- Dargan, K.S. and Gaul, G.L. 1974. *Fert. News*, **19** : 24.
- Ghassemi, f., Jakemen, A.J. and Nix, H.A. (1995) Salinization of land and water resources : Human causes, extent, management and case studies. Pub. Center for resources and environmental studies. ANU, Canberra ACT, 200 Australia, pp. 526.
- Jackson, M.L 1967. Soil chemical analysis. Prentice Hall Inc. England. Cliff N.J.
- Lal, B. (1997). Technological options for wasteland development : In Advances in wastelands development pp-93-104 (Ed. Sarkar, et al.) Pub. Soil Conservation Society of India, New Delhi.
- Pandey, N., Dhurandhar, R.L. and Tripathi, R.S. 2000. *Oryza* **37**(1) : 60-62.
- Ram, S. and Rao, K.S. 1995. *Oryza*, **32** : 136-137.
- Salam, Abdul and Subramanian , S. 1988. *Indian J. Agric. Sci.*, **58** : 190-193.

MORPHO-AGRONOMIC VARIABILITY IN SYNTHETIC HEXAPLOID WHEATS DERIVED FROM TRITICUM TURGIDUM X T. TAUSCHII

R.B. RAM AND S.S. SINGH

Division of Genetics
Indian Agricultural Research Institute, New Delhi - 110012

ABSTRACT

A morpho-agronomic study of 42 synthetic hexaploid wheats (SHWs) ($2n = 6x = 42$) derived from *Triticum turgidum* ($2n = 4x = 28$) x *T. tauschii* ($2n = 2x = 14$) crosses was undertaken to establish easily usable morphological descriptors and classify them for subsequent use in wheat breeding. The observations were recorded on 22 morpho-agronomic traits, namely, leaf blade colour, leaf sheath colour, flag leaf angle, straw strength, tiller angle, glume pubescence, glume colour, spike density, awnedness, threshing behaviour, culm length, leaf area, spike length, awn length, 1000-grain weight, number of grains per spike and grain yield per plant. Data on quantitative traits subjected to cluster analysis using unweighted pair groups mean arithmetic cluster analysis (UPGMA) method resulted in classifying the SHWs accession into three distinct phenotypic groups. The genotypes tested were exhibited substantial variability for morpho-agronomic traits. Observation were also demonstrated that simple taxonomic descriptions and grouping of SHWs may be useful in wheat breeding programme.

Key words : Cluster analysis, synthetic hexaploid wheat, *Aegilops squarrosa*, *Triticum aestivum*, wheat descriptors.

Wheat, the most important component of the grain basket of the world, has received stagnation in terms of quantitative and qualitative yield potential due to lack of efficient utilization of untouched natural variability for yield attributes. Goatgrass [(*Triticum aestivum* (coss.) Schmal, formerly *Aegilops squarrosa* L.)] constitute a relatively untapped germplasm pool for broadening the genetic base of common hexaploid wheat. This diploid species, the donor of the D-genome to the common hexaploid wheat was evaluated by several workers (Dyck and Kerber, 1970. Gill *et al.*, 1985 and Gill *et al.*, 1986) and it has been reported to be a source of resistance/tolerance to biotic and abiotic stresses. It also appears to a potent source of new variability for important yield components. For efficient utilization of *T. tauschii* as a source of disease and insect resistance and other agronomic traits, synthetic hexaploid wheats (SHWs) were derived from *T. turgidum* x *T. tauschii* by hybridization and chromosome doubling of F₁ sterile hybrid (Mujeeb-Kazi *et al.*, 1987). Before utilizing this reservoirs of genetic diversity for

wheat improvement, it is necessary to establish readily usable morphological descriptors and classify them using cluster analysis (Villareal *et al.*, 1994). The present investigation, was undertaken to study morpho-agronomic variability and grouping of SHWs based on cluster analysis on the taxonomic distance matrix of the ten quantitative characters.

MATERIALS AND METHODS

The forty two Synthetic hexaploid wheats (SHWs) received from CIMMYT, Mexico, were used to study the morpho-agronomic variability for yield contributing traits. The pedigree of synthetic hexaploid wheats are presented in Table 1.

The experiment was conducted at Experimental Farm, I.A.R.I., New Delhi in a randomized block design with three replications. Each accession was planted in a three rows plot, each 2.5m long with row to row distance of 30 cm and seed to seed distance of 10 cm. All the recommended practices were followed to raise

Table 1. Cross/pedigrees of synthetic hexaploid wheats

S.No.	Synthetics	Name or Cross/ pedigree
1	Syn. 2	DOY1/ <i>Ae. squarrosa</i>
2	Syn. 4	ALTAR 84/ <i>Ae. squarrosa</i>
3	Syn. 5	ALTAR 84/ <i>Ae. squarrosa</i>
4	Syn. 9	ALTAR 84/ <i>Ae. squarrosa</i>
5	Syn. 12	ROK/KML/ / <i>Ae. squarrosa</i>
6	Syn. 14	YUK/ <i>Ae. squarrosa</i>
7	Syn. 18	D67.2/P66.270/ / <i>Ae. squarrosa</i>
8	Syn. 19	AVERD 2/ <i>Ae. squarrosa</i>
9	Syn. 26	ACO 89/ <i>Ae. squarrosa</i>
10	Syn. 27	GARZA/BOY/ / <i>Ae. squarrosa</i>
11	Syn. 29	68.111/RGB-U/ /WARD/3/ <i>Ae. squarrosa</i>
12	Syn. 33	YAV3/SCO/ /JO69/CRA/3/YAV79/4/ <i>Ae. squarrosa</i>
13	Syn. 35	68.111/RGB-U/WARD/3/ <i>Ae. squarrosa</i>
14	Syn. 36	CROC 1/ <i>Ae. squarrosa</i>
15	Syn. 37	68.111/RGB-U/ /WARDRESEL/3/STIL/4/ <i>Ae. squarrosa</i>
16	Syn. 39	CROC 1/ <i>Ae. squarrosa</i>
17	Syn. 40	68.111/RGB-U/ /WARDRESEL/3/STIL/4/ <i>Ae. squarrosa</i>
18	Syn. 41	68.111/RGB-U/ /WARD/RESEL/3/STIL/4/ <i>Ae. squarrosa</i>
19	Syn. 42	YAR/ <i>Ae. squarrosa</i>
20	Syn. 43	YUK/ <i>Ae. squarrosa</i>
21	Syn. 44	68.111/RGB-U/ /WARD/3/FGO/4/RABI/5/ <i>Ae. squarrosa</i>
22	Syn. 45	68.111/RGB-U/ /WARD/3/FGO/4/RABI/5/ <i>Ae. squarrosa</i>
23	Syn. 46	CROC/1/ <i>Ae. squarrosa</i>
24	Syn. 47	68.111/RGB-U/ /WARD/3/FGO/4/RABI/5/ <i>Ae. squarrosa</i>
25	Syn. 48	SORA/ <i>Ae. squarrosa</i>
26	Syn. 50	CROC1/ <i>Ae. squarrosa</i>
27	Syn. 51	PBW 114/ <i>Ae. squarrosa</i>
28	Syn. 52	ALTAR 84/ <i>Ae. squarrosa</i> (JBANGOR)
29	Syn. 53	YAV2/TEZ/ / <i>Ae. squarrosa</i>
30	Syn. 55	GAN/ / <i>Ae. squarrosa</i>
31	Syn. 56	D67.2/P66.270/ / <i>Ae. squarrosa</i>
32	Syn. 59	SRN/ <i>Ae. squarrosa</i>
33	Syn. 60	SCOOP1/ <i>Ae. squarrosa</i>
34	Syn. 62	SCA/ <i>Ae. squarrosa</i>
35	Syn. 63	YAR/ <i>Ae. squarrosa</i>
36	Syn. 65	BOTNO/ <i>Ae. squarrosa</i>
37	Syn. 68	D67.2/P66.270/ / <i>Ae. squarrosa</i>
38	Syn. 74	YAV2/TEZ/ / <i>Ae. squarrosa</i>
39	Syn. 75	ARLIN/ <i>Ae. squarrosa</i>
40	Syn. 86	DOY1/ / <i>Ae. squarrosa</i>
41	Syn. 88	CPI/GEDIZ/3/GOD/ /JO69/CRA/4/ <i>Ae. squarrosa</i>
42	Syn. 90	ALTAR84/ <i>Ae. squarrosa</i>

a good crop. Ten randomly plants from middle row of each test plot were taken to minimize border effects to observe and record their morpho-agronomic descriptions and measurements. The wheat descriptors were based on those used at CIMMYT and IBPGR (CIMMYT, 1985 and IBPGR, 1985). The observations were recorded on 22 morpho-agronomic traits, namely, leaf blade colour, leaf sheath colour, flag leaf angle, straw strength, tiller angle, glume pubescence, glume colour, spike density, awnedness, threshing behavior, grain colour, grain hardness, days to anthesis, days to physiological maturity, plant height, culm length, leaf area, spike length, awn length, 1000-grain weight, number of grains per spike and yield per plant. Cluster analysis was followed based on taxonomic distance matrix for the ten quantitative characters of the synthetic hexaploid wheats. These distances were used to construct a dendrogram using unweighted Pair Groups Mean Arithmetic cluster Analysis (UPGMA) method (Nei and Li, 1979).

RESULTS AND DISCUSSION

Observation on morpho-agronomic characters of the synthetic hexaploid wheats are presented in Tables 2 and 3.

Description of morpho-agronomic characters

Morpho-agronomic characters description are presented in table 2 studies on leaf characteristics including leaf blade colour, leaf sheath colour and flag leaf angle exhibited diverse morphological differences (Table 2). The leaf blade coloration patterns were varied from green to dark green and in some cases, with traces of purple. Leaf sheath colour was varied from green, darkgreen, purple trace to waxy (Syn. 50). Of the synthetics evaluated, more than 60 per cent had dropping, 23 per cent had semi-erect and 14 per cent had erect position of flag leaf angle.

The straw strength was varied among the synthetics and around 60 per cent of the materials had lodge straw and lodged at maturity. The tiller angle generally of the spreading (57 percent) followed by intermediate (36 percent) and the rest of the synthesis had compact (7

percent) growth habit. Lodge culm with spreading growth habit is highly related to lodging susceptibility in wheat (Villareal *et al.*, 1994).

About 70 percent of synthetics showed pubescent characters of the glume. This variation for glume pubescence was indicated by the density of trichomes present on the lemma and palea after full bloom. The glume colouration was varied from white to purple to black and to red to brown and most of the synthetics showed purple to brown colouration of the glume. All the synthetics were fully awned, and 76 per cent had conspicuous awns (awned) while 24 per cent had short awns (awnlette). Awns were found green at flowering stage in all the synthetics but at maturity 69 percent of the awn colours changed to back. Out of 42 synthetics, 10 had hard, 23 had medium and only one (Syn. 50) had free threshing behavior. This characteristic could be partly explained by the action of the gene located on q locus and inherited from the *T tauschii* (Morris and Sears, 1967).

Among the test material, dark red grain colour was highest followed by light red and red. Synthetic 50 and 74 had amber grain colour. Most of the synthetics had semi-hard or hard grains. The degree of seed shriveling was high among the synthetics. High degree of shriveling of seed and had deep crease are indication of poorly-formed wheat grains.

Measurement of morpho-agronomic characters

Measurement of morpho-agronomic characters which are quantitative in nature are presented in table 3. The longest duration anthesis was found in Syn.65 and Syn.60 (124 days) whereas the shortest duration anthesis (107 days) and fastest to maturity (137.67 days) was found in Syn.50. Synthetic 42 (154.33 days) and Syn.62 (154 days) were latest maturing followed by Syn.60 (153 days) Syn.47 and Syn.2 (152 days). The tallest genotype was Syn. 42 (130.60 cm) whereas the shortest genotype was Syn.65 (77.73 cm). Followed by Syn. 50 (81.87 cm). The highest mean culm length (119.17 cm.) and shortest mean culm length (66.29 cm) was recorded in Syn.42 and Syn.99 respectively. The maximum leaf area was found to be Syn. 65 (13.46 sq. cm) followed

Table 2. Description of twelve morpho-agronomic traits of 42 synthetic hexaploid wheats

Syn. No.	Leaf blade colour	Leaf sheath colour	Flags leaf angle	Straw strength	Tiller angle	Glume pubescence	Glume colour	Spike density	Awned ness	Threshing behaviour	Grain colour	Grain hardness
SYN. 2	Dark green	Green	Drooping	Weak	Spreading	Pubescent	White	Intermediate	Awnette	Hard	Light red	Semi-hard
SYN. 4	Green	Green	Drooping	Lodge	Intermediate	Non pubescent	White	Dense	Awned	Medium hard	Dark red	Semi-hard
SYN. 5	Dark green	Green	Drooping	Weak	Intermediate	Non pubescent	White	Dense	Awnette	Hard	Dark red	Hard
SYN. 9	Green	Dark green	Erect	Weak	Spreading	Non pubescent	White	Very Dense	Awnette	Hard	Light red	Hard
SYN. 12	Green	Dark green	Drooping	Lodge	Spreading	Non pubescent	Purple to black	Intermediate	Awnette	Hard	Dark red	Hard
SYN. 14	Green	Purple trace	Semi erect	Weak	Spreading	Pubescent	White	Intermediate	Awned	Hard	Light red	Hard
SYN. 18	Green	Green	Drooping	Lodge	Compact	Non pubescent	White	Lax	Awnette	Hard	Light red	Semi-hard
SYN. 19	Dark green	Green	Drooping	Weak	Intermediate	Pubescent	Purple to black	Intermediate	Awned	Medium hard	Dark red	Hard
SYN. 26	Dark green	Purple trace	Drooping	Weak	Intermediate	Pubescent	White	Intermediate	Awnette	Medium hard	Light red	Semi-hard
SYN. 27	Green	Green	Drooping	Weak	Spreading	Pubescent	Purple to black	Intermediate	Awned	Hard	Dark red	Semi-hard
SYN. 29	Dark green	Green	Drooping	Lodge	Spreading	Pubescent	Purple to black	Intermediate	Awned	Medium hard	Dark red	Hard
SYN. 33	Green	Green	Drooping	Lodge	Spreading	Pubescent	Red to brown	Intermediate	Awned	Hard	Red	Hard
SYN. 35	Green	Dark green	Drooping	Strong	Spreading	Pubescent	Red to brown	Intermediate	Awned	Medium hard	Light red	Semi-hard
SYN. 36	Dark green	Purple trace	Drooping	Lodge	Spreading	Pubescent	White	Lax	Awned	Medium hard	Light red	Semi-hard
SYN. 37	Green	Green	Semi erect	Lodge	Spreading	Pubescent	Red to brown	Intermediate	Awned	Hard	Dark red	Hard
SYN. 39	Green	Green	Drooping	Lodge	Intermediate	Pubescent	Purple to black	Intermediate	Awned	Medium hard	Dark red	Semi-hard
SYN. 40	Green	Green	Drooping	Lodge	Spreading	Pubescent	Red to brown	Intermediate	Awned	Medium hard	Red	Hard
SYN. 41	Dark green	Purple trace	Drooping	Lodge	Intermediate	Non pubescent	Purple to black	Lax	Awned	Medium hard	Dark red	Semi-hard
SYN. 42	Green	Green	Semi erect	Lodge	Spreading	Non pubescent	Red to brown	Lax	Awned	Medium hard	Dark red	Hard
SYN. 43	Green	Green	Semi erect	Lodge	Spreading	Pubescent	White	Intermediate	Awned	Medium hard	Dark red	Hard

contd...

Table 2 contd...

SYN. 44	Green	Dark green	Drooping	Lodge	Spreading	Pubescent	Purple to black	Dense	Awned	Hard	Red	Semi-hard
SYN. 45	Dark green	Green	Semi erect	Lodge	Spreading	Pubescent	Purple to black	Intermediate	Awned	Hard	Dark red	Hard
SYN. 46	Dark green	Dark green	Semi erect	Strong	Intermediate	Pubescent	Purple to black	Intermediate	Awned	Medium hard	Dark red	Hard
SYN. 47	Green	Green	Drooping	Weak	Intermediate	Pubescent	White	Intermediate	Awned	Medium hard	Red	Semi-hard
SYN. 48	Green	Green	Drooping	Lodge	Spreading	Pubescent	Red to brown	Intermediate	Awned	Hard	Red	Semi-hard
SYN. 50	Green	Waxy	Erect	Weak	Compact	Pubescent	White	Very dense	Awned	Free threshing	Amber	Hard
SYN. 51	Green	Green	Erect	Weak	Spreading	Non pubescent	Purple to black	Dense	Awned	Medium hard	Light red	Hard
SYN. 52	Green	Dark green	Drooping	Lodge	Spreading	Pubescent	Purple to black	Very dense	Awnette	Hard	Light red	Hard
SYN. 53	Green	Purple trace	Erect	Strong	Intermediate	Pubescent	Purple to black	Very dense	Awned	Medium hard	Light red	Semi-hard
SYN. 55	Green	Green	Erect	Lodge	Compact	Non pubescent	Red to brown	Very lax	Awned	Medium hard	Dark red	Semi-hard
SYN. 56	Green	Green	Semi erect	Lodge	Spreading	Pubescent	Red to brown	Intermediate	Awnette	Medium hard	Light red	Soft
SYN. 59	Dark green	Purple trace	Drooping	Weak	Spreading	Pubescent	Red to brown	Intermediate	Awnette	Medium hard	Light red	Soft
SYN. 60	Green	Green	Semi erect	Lodge	Spreading	Pubescent	Red to brown	Dense	Awned	Medium hard	Red	Soft
SYN. 62	Dark green	Dark green	Drooping	Strong	Spreading	Pubescent	Red to brown	Intermediate	Awnette	Medium hard	Light red	Semi-hard
SYN. 63	Dark green	Green	Drooping	Lodge	Intermediate	Pubescent	Red to brown	Intermediate	Awned	Hard	Red	Semi-hard
SYN. 65	Dark green	Green	Drooping	Lodge	Intermediate	Pubescent	Purple to black	Intermediate	Awned	Hard	Dark red	Hard
SYN. 68	Green	Purple trace	Semi erect	Weak	Spreading	Pubescent	White	Intermediate	Awned	Medium hard	Light red	Soft
SYN. 74	Green	Green	Drooping	Lodge	Intermediate	Non pubescent	Red to brown	Intermediate	Awned	Medium hard	Amber	Semi-hard
SYN. 75	Dark green	Dark green	Drooping	Lodge	Spreading	Pubescent	Purple to black	Intermediate	Awned	Hard	Dark red	Semi-hard
SYN. 86	Purple trace	Purple trace	Drooping	Weak	Intermediate	Non pubescent	Purple to black	Dense	Awned	Hard	Red	Soft
SYN. 88	Dark green	Green	Erect	Lodge	Intermediate	Non pubescent	White	Intermediate	Awned	Hard	Red	Semi-hard
SYN. 90	Dark green	Green	Semi erect	Lodge	Intermediate	Non pubescent	Red to brown	Dense	Awned	Medium hard	Light red	Semi-hard

Table 3. Mean performances of 42 synthetic hexaploid wheats with respect to 10 morpho-agronomic traits

Syn No.	Days to anthesis	Days to Phys. maturity	Plant height (cm)	Culm length (cm)	Leaf area (sq. cm)	Spike length (cm)	Awn length (cm)	1000-grain wt. (g)	No. of grains/spike	Grain Yield/plant (g)
SYN. 2	123.67	152.00	100.73	89.74	6.55	10.99	5.02	40.72	22.52	4.74
SYN. 4	116.33	141.33	94.33	85.33	10.24	9.00	6.71	27.44	31.36	4.63
SYN. 5	117.33	140.67	109.80	99.19	7.05	10.61	4.91	40.39	18.30	4.00
SYN. 9	118.00	149.67	112.73	100.66	13.46	12.07	5.52	41.29	33.98	7.63
SYN. 12	114.33	148.33	94.53	84.01	9.47	10.53	5.55	44.06	23.42	5.94
SYN. 14	122.67	147.33	105.07	93.05	5.92	12.02	4.53	41.76	11.96	2.84
SYN. 18	117.33	140.00	112.40	101.69	8.83	10.71	2.71	36.88	18.40	2.92
SYN. 19	121.33	150.33	105.27	94.27	8.54	11.20	6.81	34.74	16.88	3.13
SYN. 26	120.00	144.33	127.73	115.80	11.12	11.94	4.21	42.59	26.31	6.69
SYN. 27	115.67	142.33	113.73	100.81	10.20	12.92	4.71	36.95	23.14	5.78
SYN. 29	116.00	148.33	122.00	107.82	10.10	14.18	7.36	38.05	21.89	6.30
SYN. 33	120.67	150.67	9.73	89.43	8.79	10.30	5.27	35.56	25.29	4.33
SYN. 35	120.67	150.00	123.87	113.58	8.00	10.29	4.43	37.23	18.85	2.73
SYN. 36	120.67	149.00	115.73	105.17	8.30	10.59	5.53	33.65	16.71	2.01
SYN. 37	120.33	147.67	111.33	101.95	6.10	9.38	4.29	22.72	11.69	2.87
SYN. 39	119.00	150.67	106.20	96.92	9.40	9.28	4.65	41.05	19.91	5.00
SYN. 40	121.00	149.67	94.53	84.09	9.45	10.44	6.61	43.81	19.61	5.03
SYN. 41	109.00	139.33	102.47	90.03	10.70	12.43	4.99	34.34	1.74	4.93
SYN. 42	122.67	154.33	130.60	119.17	9.46	11.43	5.07	31.60	23.28	3.29
SYN. 43	117.67	148.67	109.87	99.54	8.53	10.33	6.66	39.70	22.14	4.93

contd.:

Table 3 contd...

SYN. 44	116.00	144.00	117.47	105.41	10.13	12.06	4.90	44.20	20.93	6.45
SYN. 45	118.00	150.33	120.99	109.77	9.98	11.13	4.01	43.03	22.06	6.92
SYN. 46	115.67	143.00	116.20	104.92	10.61	11.28	6.63	46.29	37.72	8.50
SYN. 47	120.33	152.67	97.00	87.05	10.52	9.95	4.75	34.39	19.96	4.26
SYN. 48	121.67	151.33	117.27	104.93	6.71	12.34	5.37	38.03	18.57	5.01
SYN. 50	107.67	137.67	81.87	79.29	6.00	5.91	14.30	38.99	36.98	8.01
SYN. 51	116.00	146.67	104.73	94.36	8.35	10.37	5.52	46.63	25.63	8.51
SYN. 52	122.33	150.67	104.10	92.60	6.41	11.50	3.04	38.92	23.56	6.58
SYN. 53	118.00	145.33	112.40	103.60	8.53	8.80	6.59	46.13	16.31	6.12
SYN. 55	113.67	139.00	111.13	101.87	8.49	9.27	3.59	37.60	43.04	7.98
SYN. 56	119.67	150.00	111.27	100.03	7.13	11.23	4.95	35.49	23.38	3.68
SYN. 59	119.00	144.67	118.00	108.09	10.03	9.91	5.95	41.82	17.39	3.98
SYN. 60	124.33	153.33	91.27	81.29	8.42	9.98	4.83	45.29	13.74	2.82
SYN. 62	123.00	154.00	126.80	116.51	9.57	10.29	5.72	36.98	20.83	4.09
SYN. 63	117.33	1489.67	126.60	1140.95	8.95	11.65	5.96	45.23	14.56	3.26
SYN. 65	124.33	152.00	77.73	66.29	9.20	11.45	5.05	32.47	15.82	2.28
SYN. 68	120.67	145.00	124.67	113.68	6.59	10.99	4.84	39.63	15.73	2.81
SYN. 74	117.33	145.00	119.40	107.54	9.78	11.86	6.59	54.20	36.90	5.11
SYN. 75	119.33	146.00	103.40	88.67	8.36	14.79	5.18	37.80	21.76	3.44
SYN. 86	120.33	144.67	122.20	113.85	10.39	10.68	4.59	35.37	15.78	3.18
SYN. 88	112.00	142.00	96.73	86.54	10.09	10.20	4.42	27.17	37.00	8.01
SYN. 90	115.50	143.00	107.13	95.81	10.75	11.32	5.05	35.98	26.06	3.54
C.D. (5%)	4.08	4.70	3.61	3.55	0.82	0.35	0.16	3.27	1.98	0.80

by Syn. 26 (11.12 sq.cm.) while Syn. 14 had the minimum leaf area (5.92 sq.cm.).

Spike and grain characteristics including spike length, awn length 1000-grain weight, number of grains per spike and yield per plant are depicted in table 3 representing a unique variability for the morpho-agronomic characters. The spike length ranged from 14.75 cm (Syn. 75) to 5.91 cm (syn. 50). The Syn. 18 had shortest

awn length (2.81 cm) while Syn. 50 had highest awn length (14.30 cm). The genotype having the heaviest grain was Syn. 74 (54.20 g) followed by Syn. 51 (46.63 g). and syn. 46 (46.29 g). The genotype with the lightest grains was Syn. 37 (22.72 g). The genotype having maximum number of grains per spike was syn. 55 (43.04) whereas Syn. 37 having the minimum number of grains per spike (11.69). The highest mean value for

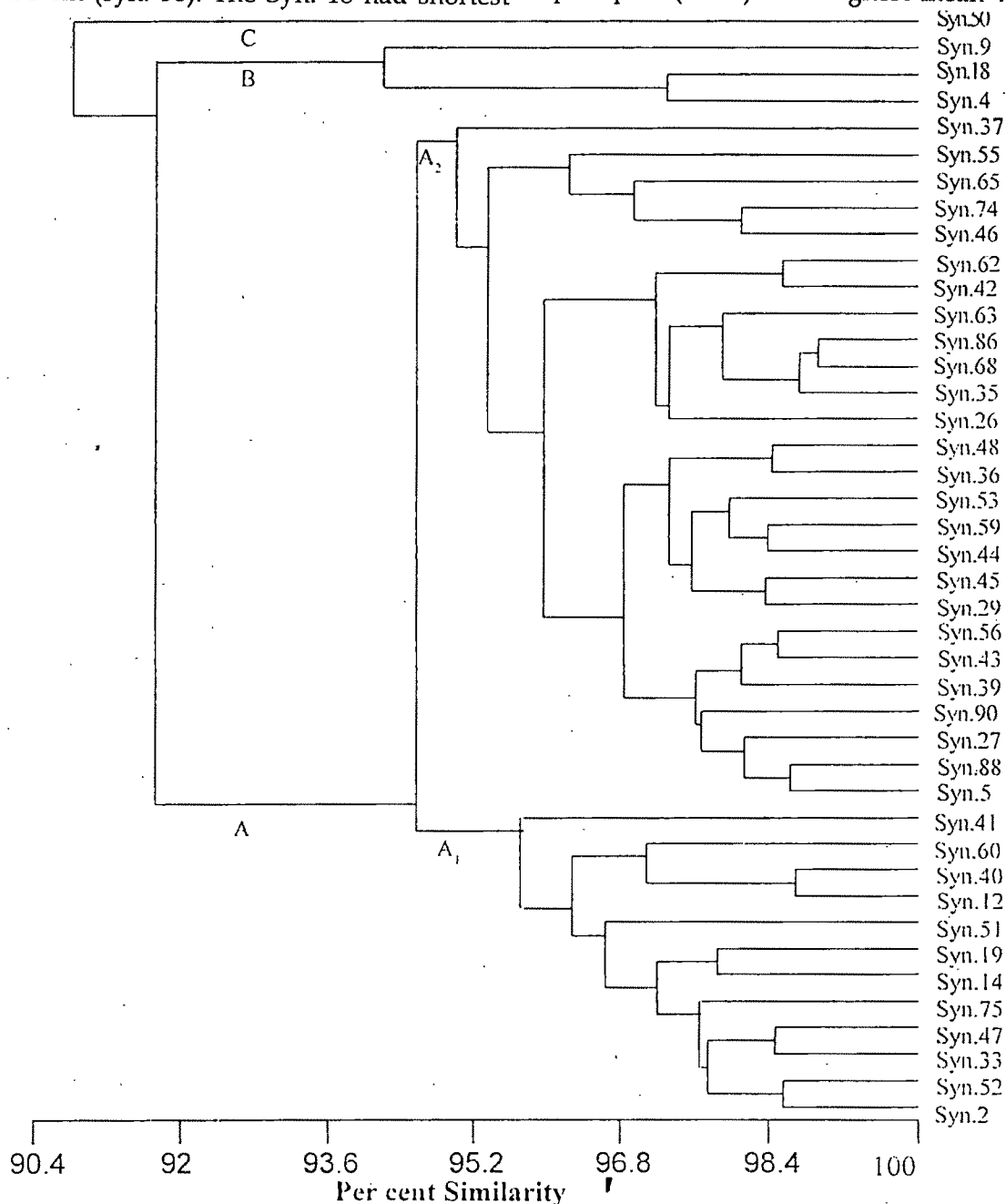


Fig. 1. Dendrogram of Standard taxonomic similarity per cent of 42 synthetic hexaploid wheat genotypes constructed from 10 quantitative characters

yield per plant was noted for Syn.51 (8.51 g) and lowest mean value was observed for Syn.36 (2.01 g). Villareal *et al.* (1994) were also studied the thirty fine qualitative and quantitative traits of leaves, culm, glumes, spike and grains of synthetic hexaploid wheats and reported substantial variability in each entry.

Standard taxonomic distances

Clustering of genotypes based upon the similarity of characters. Using the numerical taxonomic distance method, the ten quantitative characters were used for studying taxonomic distances among forty two synthetic hexaploid wheat genotypes. The clusters formed have been depicted in the form of dendrograms (Fig. 1) and the genetic distance among synthetic hexaploid wheat genotypes is presented by using (100-similarity percentage) formulae.

The results indicated maximum similarity between Syn. 68 and Syn. 86 (98.94%) and minimum similarity between Syn. 63 and Syn. 50 (90.16%). The range of similarity percentage among synthetic wheats varied from 1.06% to 13.62%.

The UPGMA cluster dendrogram of genetic distance among forty two synthetic wheats showed three major cluster (A, B and C). Cluster A further subdivided into two subgroups (A1 and A2). Cluster A including thirty eight genotypes, cluster B three genotypes and clusters C only one genotype. The subgroup A1 had twelve genotypes namely, Syn. 2, 12, 14, 19, 33, 40, 41, 47, 51, 52, 60 and 75 and subgroup A2 had largest number of genotypes including Syn.5, 26, 27, 29, 35, 36, 37, 39, 42, 43, 44, 45, 46, 48, 53, 55, 56, 59, 62, 63, 65, 68, 74, 86, 88 and 90. The cluster B had three genotypes (Syn.4, 9 and 18) while cluster C consisting only one distinct genotype, Syn.50.

The distinctive combinations of genotypes and morpho-agronomic traits were appeared in each of the three major groups of materials. The relatively simple taxonomic description and grouping of synthetic hexaploid wheats may be useful in wheat breeding. Moreover, Syn. 46 and Syn. 65 possess high level of seedling resistance to race 77-5 of leaf rust (Personal communication) as well as comparatively significant desirable morpho-agronomic traits. Therefore, these two SHWs may be directly used in wheat improvement programmes.

REFERENCES

- CIMMYT. 1985. Instructions for the management and reporting of results for the CIMMYT Wheat Program International Nurseries. Mexico, D.F., 19p.
- Dyck, P.L. and Kerber, E.R. 1970. Inheritance in hexaploid wheat of adult-plant leaf rust resistance derived from *Aegilops squarrosa*. *Can. J. Genet. Cytol.*, **12**: 175-180.
- Gill, B.S., Raupp, W.J., Sharma, H.C. Browder, L.E., Hatchett, J.H., Harvey, T.L., Moseman, J.G. and Waines, J.G. 1986. Resistance in *Aegilops squarrosa* to wheat leaf rust, wheat powdery mildew, greenbug, and Hessian fly. *Plant Dis.*, **70**: 553-556.
- Gill, B.S., Sharma, H.C. and Raupp, W.J. 1985. Evaluation of *Aegilops* species for resistance to wheat powdery mildew, wheat leaf rust, Hessian fly, and greenbug. *Plant Dis.*, **69**: 314-316.
- IBPGR. 1985. Revised descriptors for wheat. International Board for Plant Resources, Rome, 12p.
- Morris, R. and Sears, E.R. 1967. The cytogenetics of wheat and its relatives of hexaploid wheat. *Can. J. Bot.*, **59**: 572-573.
- Mujeeb-Kazi, A., Roldon, S., Duh, D.Y., Sitch, L.A. and Farooq, S. 1987. Production and cytogenetic analysis of hybrids between *Triticum aestivum* and some caespitose *Agropyron* species. *Genome*, **29**: 537-553.
- Nei, M. and Li, W.H. 1979. Mathematical model for studying genetic variation in terms of restriction endonucleases. *Proc. Natl. Acad. Sci. (USA)*, **76**: 5269-5273.
- Villareal, R.L., Mujeeb-Kazi, A., Rajaram, S. and Del Toro, B. 1994. Morphological variability in some synthetic hexaploid wheats derived from *Triticum turgidum* x *T. tauschii*. *J. Genet. Breed.*, **48**: 7-16.

CORRELATION AND PATH ANALYSIS OF HYBRIDS AND PARENTS IN PEARL MILLET

K.V. UNNIKRISHNAN, BALZOR SINGH, RAMESH SINGH, A.P.S. VERMA AND K.P. SINGH .

*Division of Genetics
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Genotypic correlation coefficient and path coefficient analysis carried out in 244 genotypes of pearl millet showed highly significant positive correlations of ear girth, ear length, days to 50% flowering and 1000 grain weight with grain yield. The results of the path analysis revealed that the direct contribution of ear girth was maximum on grain yield followed by ear length, plant height and 1000 grain weight.

Key words : Correlation, path coefficient, pearl millet.

Grain yield is a complex trait, which is influenced by many independent traits and its improvement is essentially linked with deep understanding of interrelationship between them. Studies on the correlation of traits and their relative direct and indirect effect on yield are important, as they are helpful in selecting desirable traits. Hence, an attempt was made to study 244 genotypes of pearl millet for correlation and path coefficients on the basis of data recorded for seven characters.

MATERIALS AND METHODS

Two hundred and forty four genotypes consisting of six male sterile lines, thirty-four restorers and 204 hybrids of pearl millet were planted in a randomized block design with three replications during kharif 2001 at IARI, New Delhi. All the genotypes were evaluated in a 3 m long single row plot with spacing of 45 cm × 15 cm between the rows and plants, respectively. Data were recorded on ten randomly selected plants from each plot on days to 50% flowering, plant height, effective tillers per plant, ear length, ear girth, 1000 grain weight and grain yield per plant. The data were subjected to statistical analysis for genotypic correlations and path analysis, as per method suggested by Johnson *et al.* (1955) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

In the present study, the genotypic correlation between important yield attributing characters and grain yield per plant revealed that the grain yield and ear length showed highly significant correlation (Table 1). Similarly, grain yield with ear girth, plant height, 1000 grain weight, effective tillers per plant and days to 50% flowering also showed highly significant correlation. These findings suggest that the selection for these characters is likely to contribute towards higher yield.

Other character pairs which showed positive and highly significant association were 1000 grain weight with ear girth, plant height, ear length and days to 50% flowering; ear girth with days to 50% flowering, ear length, plant height and effective tillers per plant, ear length with plant height. These results indicate that simultaneous selection is possible for all these characters. It can be concluded that by making selection for grain yield, the maximum weightage should be given for ear length followed by ear girth, 1000 grain weight and effective tillers per plant.

In the present study a positive association of flowering time with grain yield has been observed. In normal selection procedure, it is not easy to break this undesirable association of plant

Table 1. Genotypic correlation coefficient among seven characters in parents and hybrids of pearl millet

Characters	Days to 50% flowering	Plant height	Effective tillers/ plant	Ear length	Ear girth	1000 grain weight	Grain yield
Days to 50% flowering	1.0000	0.0582	0.1145*	0.0792	0.4109**	0.1845**	0.1311**
Plant height		1.0000	-0.0994	0.5565**	0.2818**	0.4030**	0.5713**
Effective tillers/plant			1.0000	-0.0388	0.1753**	-0.0270	0.1771**
Ear length				1.0000	0.3345**	0.3709**	0.5887**
Ear girth					1.0000	0.5654**	0.5760**
1000 grain weight						1.0000	0.5193**
Grain yield							1.0000

*, ** Significant at 5% and 1% level, respectively

Table 2. Genotypic path coefficient among seven characters in parents and hybrids of pearl millet

Characters	Days to 50% flowering	Plant height	Effective tillers/ plant	Ear length	Ear girth	1000 grain weight	Genotypic correlation with yield
Days to 50% flowering	-0.0842	0.0127	0.0197	0.0222	0.1365	0.0242	0.1311**
Plant height	-0.0049	0.2175	-0.0171	0.1563	0.0936	0.0528	0.5713**
Effective tillers/plant	-0.0096	-0.0216	0.1724	-0.0109	0.0582	-0.0035	0.1771**
Ear length	-0.0067	0.1210	-0.0067	0.2808	0.1111	0.0486	0.5887**
Ear girth	-0.0346	0.0613	0.0302	0.0939	0.3321	0.0741	0.5760*
1000 grain weight	-0.0155	0.0877	-0.0047	0.1041	0.1878	0.1311	0.5193**

Bold figures in diagonal denotes direct effect

Residual effect : 0.4502

*, ** Significant at 5% and 1% levels, respectively

height and maturity with yield. However, Comstock *et al.* (1949) and Rao and Krishnamurty (1968) have pointed out the possibility of breakage of such undesirable phase linkages through reciprocal recurrent selection. The breakage of this unfavorable linkage in this crop would overcome the plateau of limited response to selection for grain yield imposed by plant height and flowering time.

The genotypic correlation coefficient of grain yield with other yield components under study were further partitioned into direct and indirect effect using path coefficient analysis and the estimates are given in Table 2. The results of the path analysis revealed that the direct contribution of ear girth was maximum (0.3321) followed by ear length (0.2808), plant height (0.2175) and 1000 grain weight (0.1311). This was evident from their high direct positive effects on yield. The indirect effect of ear girth, ear length, plant height and 1000 grain weight on grain yield through other characters were very

small. These results were also substantiates the findings of Pokhriyal *et al.* (1967) and Dhillon *et al.* (1977). The present investigation indicates that maximum positive direct effect on grain yield contributed by ear girth, plant height and 1000 grain weight were sufficient enough to nullify the small indirect effect made by these traits on grain yield. Similarly, the indirect effect of effective tillers per plant on grain yield was very small and negative.

From this study, it was obvious that the indirect effect was maximum for ear girth via 1000 grain weight; ear length via plant height; ear girth via days to 50% flowering; plant height via ear length; ear girth via ear length and 1000 grain weight. Therefore, on the basis of results obtained, it can be concluded that during selection major emphasis should be given on ear girth followed by ear length, plant height effective tillers per plant and 1000 grain weight. The selection for these characters is bound to contribute towards higher grain yield.

REFERENCES

- Dewey, D.R. and Lu, K.H. 1959. *Agron. J.*, 51 : 515.
- Comstock, R.E., Robinson, H.F. and Harvey, P.H. 1949. *Agron. J.*, 41 : 360.
- Dhillon, B.S., Gupta, V.P. and Sethi, A.S. 1977. *Genetica Agraria.*, 31 : 411.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. *Agron. J.*, 47 : 487.
- Pokhriyal, S.C., Mangath, K.S. and Gangal, L.K. 1967. *Indian J. Agric. Sci.*, 37 : 77.
- Rao, J.T. and Krishnamurty, T.N. 1968. *Indian J. Genet.*, 28 : 88.

WHEAT YIELD AND SOIL BULK DENSITY RESPONSE TO TILLAGE, RESIDUE AND NITROGEN MANAGEMENT UNDER RICE-WHEAT SYSTEM

SANDEEP KUMAR*, D.S. PANDEY AND N.S. RANA

*Department of Agronomy
G.B. Pant University of Agriculture and Technology, Pantnagar - 263145*

ABSTRACT

For analyzing the effect of tillage, residue and nitrogen management on the productivity of wheat and soil bulk density, a field trial was conducted comprising of seven tillage and residue management options in main-plot and three nitrogen management schedules in sub-plot replicated four times in split-plot design. In general, the bulk density of 0-15 and 30-45 cm deep soil was observed lower as compared to 15-30 cm depth. In the beginning the differences in bulk density of soil under various tillage and residue treatments were significantly large but the same was narrowed down up to harvest of the crop. The bulk density of cultivated plots, irrespective of residue management, recorded just before crop sowing was observed lower than uncultivated plots at a depth of 0-15 cm, while at 15-30 cm soil depth the lower value was recorded from the deep incorporation of residue. The value of bulk density taken after crop harvest was observed lowest from the plot receiving incorporation of residue, irrespective of tillage type, at the depth of 0-15 cm only. Deep tillage incorporation of rice residue scaled higher attributes and grain yield. The lowest grain yield was registered from the residue removed traditionally tilled plot. The number of tillers generated by each plant was recorded highest from the crop received retention/incorporation of residue with conservation and deep tillage. Conservation tillage with residue retention recorded lowest test weight and highest shoot mortality. Application of 75% of total N (150 kg/ha) at sowing and rest 25% at CRI is found at par in narrowing down the C : N ratio of rice with the use of starter dose of 20 kg N/ha given at time of land preparation + 150 kg N/ha applied in two equal splits at time of sowing and CRI.

Key words : Rice-wheat, tillage, residue, nitrogen, bulk density and wheat yield.

The future of rice-wheat system lies in the augmentation of its factors productivity. In spite of using more and more inputs, the field of the system either got plateau or getting declined. This paradox stems from the decimation of soil physical, chemical and biological health. Owing to extreme land cultivation under wet conditions in rice and dry conditions in wheat led to destruction of soil structure and development of hard pan that ultimately reflected into higher bulk density against to crop growth and development. To overcome this imbroglio, there is substantive need to incorporate crop residue/organic matter into soil by proper tillage technology in such a way so that agronomic operation may easily be carried out coupled with

breakage of hard pan. This practice certainly make the soil bulk density in parlance to crop need vis a vis recuperation of soil fertility.

MATERIALS AND METHODS

An investigation was hold at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during Kharif and Rabi seasons of 1999-2000 and 2000-2001. The rice crop was grown commercially for residue incorporation whereas the wheat crop for investigation purpose since 1998-1999. The disposal of rice straw was made according to the treatments, while wheat straw was removed from the field. The experiment was laid out into Split-Plot Design with four replications. The treatments comprised of seven tillage type with rice residue management options viz. T₁-Hand

* Present address : Lecturer, Department of Agronomy, CCR (PG) College, Muzaffarnagar.

harvested field prepared by conventional method of tillage using a trailed disc harrow (6 harrow + 1 planker); T₂-Combine harvested field prepared by the operation of mould board plough followed by trailed disc harrow (1 mould board plough + 4 harrow + 1 planker); T₃-Combine harvested field prepared by operation of standard disc plough followed by trailed disk harrow (1 standard disk plough + 4 harrow + 1 planker); T₄-Combine harvested field prepared by operation of trailed disk harrow (6 harrow + 1 planker); T₅-Combine harvested field sown by Zero-till-ferti-seed-drill; T₆-Combine harvested field sown by Strip-till-ferti-seed-drill and T₇ - Combine harvesting followed by burning then field prepared by conventional method of tillage using a trailed disk harrow (6 harrow + 1 planker) in main plots and three nitrogen management options applied @ 150 kg N/ha viz.; N₁-1/2 at sowing + 1/2 at crown root initiation along with 20 kg N as starter dose given at time of field preparation; N₂-2/3 at sowing+1/3 at crown root initiation and N₃-1/2 at sowing +1/2 at crown root initiation in sub-plots. The soil was silty-clay-loam having a pH value of 7.8 with high organic carbon (1.21%) and phosphorus (29 kg/ha) and medium in potassium (240 kg/ha) status. The initial soil bulk density of 0-15, 15-30 and 30-45 cm soil depth was 1.43, 1.69 and 1.59 mg m⁻³, respectively. The rainfalls received during both the cropping seasons were 140 and 51mm, respectively. The wheat variety PBW 343 was sown on Dec. 04 and 06 in the respective years.

RESULTS AND DISCUSSION

Effect of Tillage and Residue Management

In general, the bulk density of 0-15 and 30-45 cm deep soil was observed lower as compared to 15-30 cm depth. The same was increased gradually with time on account of natural consolidation of soil particles in all the treatments up to harvest of crop. In the beginning, the differences in bulk density of soil under various tillage and residue treatments were significantly large but the same was narrowed down up to harvest of crop (Table 1) Ross and Hughes, (1985) also reported the similar findings. The bulk density measured from 0-15 and 15-30 cm

soil depth was significantly influenced due to tillage and residue management practices recorded from the prepared field just before crop sowing. The bulk density of cultivated plots, irrespective of residue management, was observed to be lower than these of uncultivated plots at a depth of 0-15 cm. Like (1986) also confirmed that bulk density of plough sole of the uncultivated land was greater than those of ploughed sole. The bulk density measured at the depth of 15-30 cm was significantly lower in combine harvested plot tilled with mould board plough followed by disc plough in comparison to other treatments which produced statistically similar bulk density. Tillage and residue treatments did not bring significant change in the bulk density measured from the depth of 30-45 cm; however, a slightly lower bulk density was measured in the plot tilled with mould board plough.

Both the tillage and residue management treatments brought significant change in bulk density taken after crop harvest only at 0-15 cm soil depth, while no-differences in bulk density values taken from 15-30 and 30-45 cm were observed. The value of bulk density at the depth of 0-15 cm was observed lower from the plot receiving incorporation of residue, irrespective of tillage type, while burning, removal and retention of residue at soil surface did not affect soil compaction and so produced lower and at par values among themselves. Walia *et al.*, (1995) also reported that incorporation of crop residues decreased bulk density (0-15 cm) compared to residue removal and burning.

Tillage and rice residue management practices brought the significant variation in growth, yield and yield attributes. The incorporation of rice residue into succeeding wheat crop with the help of either disc plough (T₃) or mould-board plough (T₂) scaled statistically similar highest grain yield (table-2). The observation recorded by Bhadoria (1988) was also in same line. Either burning (T₇) or incorporation of rice residue by traditional tillage (T₄) or leaving the rice residue on soil surface using zero-till (T₅) or strip-till-ferti-seed drill (T₆) did not bring any significant differences and

Table 1. Effect of tillage/rice residue and nitrogen management on soil bulk density (Mg m^{-3}) recorded from prepared field before sowing and after harvest of wheat crop (Pooled data)

Treatments	Bulk density					
	Before sowing			After harvest		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Tillage and residue management						
Mode of harvesting	Tillage implement					
(T ₁) Hand	1.23	1.66	1.60	1.41	1.67	1.59
(T ₂) Combine	1.22	1.30	1.58	1.33	1.63	1.57
(T ₃) Combine	1.23	1.47	1.58	1.34	1.64	1.57
(T ₄) Combine	1.23	1.67	1.58	1.32	1.67	1.58
(T ₅) Combine	1.42	1.66	1.59	1.41	1.66	1.58
(T ₆) Combine	1.43	1.67	1.60	1.42	1.67	1.57
(T ₇) Combine + Burning	1.24	1.66	1.59	1.42	1.66	1.57
C.D. (P=0.05)	0.07	0.06	NS	0.07	NS	NS
Nitrogen management (kg N/ha)						
Starter dose	Basal	CRI				
(N ₁) 20	75	1.29	1.60	1.37	1.66	1.57
(N ₂) -	100	1.29	1.59	1.39	1.65	1.57
(N ₃) -	75	1.29	1.58	1.38	1.67	1.58
C.D. (P=0.05)		NS	NS	NS	NS	NS

Table 2. Effect of tillage/rice residue and nitrogen management on the productivity of wheat (Pooled data)

Treatments	Tillers/plant	Shoot mortality (%)	Effective shoots (m ⁻²)	Test weight (g)	Grain yield (t/ha)
Tillage and residue management					
Mode of harvesting	Tillage implement				
(T ₁) Hand	Harrow (6)	3.56	26.05	43.65	4.49
(T ₂) Combine	MBP(l)+Harrow(4)	4.20	26.96	43.33	5.05
(T ₃) Combine	DP(l)+harrow(4)	4.03	27.46	43.72	5.20
(T ₄) Combine	Harrow (6)	3.53	22.09	42.95	4.80
(T ₅) Combine	Zero-till-drill	4.30	31.85	42.38	4.96
(T ₆) Combine	Strip-till-drill	4.28	33.38	41.17	4.81
(T ₇) Combine + Burning	Harrow (6)	3.79	25.80	44.26	4.96
C.D. (P=0.05)		0.30	3.42	1.66	0.16
Nitrogen management (kg N/ha)					
Starter dose	Basal	CRI			
(N ₁) 20	75	4.13	29.35	390	43.14
(N ₂) -	100	3.99	29.48	391	43.58
(N ₃) -	75	3.75	28.83	375	42.48
C.D. (P=0.05)		0.19	NS	8.00	NS
					0.10

produced at par grain yield. Edminster and Meelu (1989) were also of similar views. The lowest grain yield was registered from the residue removed traditionally tilled plot (T_1). The highest grain yield recorded under the plot received incorporation of residue either by disc plough or mould-board plough, was attributed to the production of higher number of ears/m², test weight, tillers/plant and lower shoot mortality and soil bulk density.

The incorporation of rice residue into wheat field by using either mould-board plough or disc plough proved best in production of significantly higher number of ear bearing shoots while, the removal or burning of residue in wheat field prepared by traditional tillage (T_1 and T_7) scaled poorer. Burning of rice residues in the field prepared with traditional tillage (T_7) led to generation of significantly higher test weight but did not statistically substantiated superior than removal or incorporation of rice residue into wheat field either by traditional or deep tillage. Direct drilling of wheat into combine harvested rice field by strip-till-drill, being at par with zero-till-drill, fared lowest grain weight.

The number of tillers generated by each plant was recorded highest from the residue incorporation with deep tillage (T_2 and T_3) and residue retention with conservation tillage T_5 and T_6 . It was followed by residue incorporated disc plough tilled plot and residue burnt traditionally tilled plot. Incorporation of residue by traditional method (T_4) produced lowest

number of tillers/plant. Sowing of wheat crop into combine harvested rice field using Strip-till and zero-till-ferti-seed drill fared highest tiller/plant but did not sustain with its initial plant population, as evinced by the highest mortality rate, which corollary into lower effective shoots. Except strip-till and zero-till-ferti-seed drill sown plot which recorded the highest shoot mortality rate, all tillage and residue management practiced plot recorded statistically similar rate of mortality. Carnish and Lymbery (1987) did also of similar opinion of reduction in plant population in direct drilling of crop as compared to cultivated seed bed.

Effect of Nitrogen Management :

Scheduling of nitrogen brought significant variations in number of tillers produced/plant, effective shoots/plant and grain yield, while shoot mortality, test weight and soil bulk density recorded before sowing and after wheat harvest stayed unaffected. Enriching the soil with 150 kg N/ha applied into two equal splits half at sowing and remaining at CRI along starter dose of 20 kg N/ha (N_1) given at field preparation fared highest grain yield, which was statistically at par with those recorded from the plot received 150 kg N/ha only applied 2/3 as basal and remaining 1/3 at CR. (N_2). The crop that fertilized with 75 Kg n/ha as basal and the same at CRI (N_3) yielded lowest. The highest grain yield observed under treatment N_1 being at par with N_2 was the corollary of the production of highest tillers/plant and effective shoots/m².

REFERENCES

- Bhadoria, P.B.S. 1998. Influence of tillage practices on physical properties and wheat production. *Acta Agronomica Hungaria*, 37 (3-4) : 265-268.
- Carnish, P.S. and Lymbery, J.R. 1987. Reduce dearly growth of direct wheat in southern new Southwales, Causes and consequences. *Aust. J. Exptl. Agric.*, 27(6) : 869-80.
- Edminster, Y.W. and Meelu, H.F. (Jr.) 1989. Recent developments in agricultural machinery. *Adv. Agron.*, 11 : 171-232.
- Ike, I.F. 1986. Soil and crop response to different tillage practices in a terruginous and growth of wheat root system. *Acta Agriculture Shanghai* 5(1) : 61-66.
- Ross, C.W. and Hughes, K.A. 1985. Maize/oat/forage rotation under 3 cultivation system. 178-83. 2. Soil properties. *New Zealand J. Agric. Res.* 28(2) : 209-219.
- Walia, S.S.; Brar, S.S. and Kler, D.S. 1995. Effect of management of crop residues on soil properties in rice-wheat cropping system. *Environment-and-Ecology*. 13(3) : 503-507.

FORMS OF SULPHUR IN ALFISOLS AND ULTISOLS OF JHARKHAND IN RELATION TO SOIL PROPERTIES

BRAJENDRA AND L.M. SHUKLA

*Division of Soil Science and Agricultural Chemistry
India Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Soils from four districts, namely, Dhanbad, Giridih, Hazaribagh and Ranchi of Jharkhand were analysed for different fractions of S in soils such as available sulphur, total sulphur, organic sulphur, adsorbed plus soluble sulphur and these were correlated with soil properties such as pH, EC, CEC, clay, silt, sand OC, Fe_2O_3 , Al_2O_3 , CaCO_3 content. The organic form of sulphur came out to be the most dominant form of sulphur after total sulphur. Different fractions of sulphur had significant and positive correlation with salt content, OC, CEC and CaCO_3 .

Key words : Forms of sulphur, Alfisols, Ultisols, soil properties.

Acid sedentary soils of Chotanagpur plateau account for about 2 million hectares of Jharkhand. Alfisols and Ultisols dominate among the various soil orders in the region. The soils are strongly to moderately acidic in reaction (pH 4.5 to 6.5); coarse in texture (loamy sand to sandy clay loam), low in base saturation and cation exchange capacity and moderate in fertility. It is essential to study the distribution of different forms of S in soil in relation to the available sulphur status because of their interrelations. Since no such information is available for the Alfisols and Ultisols of Jharkhand, the present investigation was undertaken.

MATERIALS AND METHODS

Surface soil samples (0-15 cm) were collected in bulk from twenty different sites from plateau region of Jharkhand comprising the districts of Dhanbad, Giridih, Hazaribagh and Ranchi. The collected samples were air-dried after mixing it thoroughly. The air-dried samples were passed through 2 mm sieve. The samples were analysed for pH, electrical conductivity, organic carbon, free Fe_2O_3 , free CaCO_3 , clay, silt sand and different forms of sulphur by adopting standard procedures. The sulphur forms analysed were total S (modified Butters and Chenery's method, 1959), water soluble S

(Williams and Steinbergs, 1959), sulphate S (Williams and Steinbergs, 1959), adsorbed plus soluble S (Fox et al., 1964). Sulphur in all the extracts was determined turbidimetrically (Chesnin and Yien, 1951). The organic sulphur was evaluated by subtracting adsorbed plus sulphate sulphur from total sulphur. Simple correlation and step-wise multiple regression analysis were worked out by standard statistical methods.

RESULTS AND DISCUSSION

The soil properties of the samples and the amount of different forms of S in these soils are presented in Tables 1 and 2 respectively. The soils were found acidic to neutral in reaction and pH varied from 4.53 to 6.96. The electrical conductivity was found to vary from 0.04 dS m^{-1} , with an average value of 0.19 dS m^{-1} . The organic carbon content varied from 0.19 to 1.20 per cent, with a mean value of 0.52 per cent. The cation exchange capacity ranged from 7.50 to 15.65 $\text{cmol (p}^+) \text{ kg}^{-1}$, with a mean value of 9.54 $\text{cmol (p}^+) \text{ kg}^{-1}$. The contents of clay, sand and silt ranged from 10.20 to 23.90, 51.70 to 68.10 and 18.60 to 32.80 per cent, with the respective mean values of 16.50, 22.87 and 60.23 per cent. The content of Al_2O_3 varied from 2.90 to 4.90 per cent, with an average value of 3.89 per cent. The Fe_2O_3 content was found to range from 1.50 to 2.60 per cent,

Table 1. Important soil characteristics

Soil No.	pH	EC (ds m ⁻¹)	OC (%)	CEC (cmol(p ⁺) kg ⁻¹)	Clay (%)	Silt (%)	Sand (%)	Fe ₂ O ₃ (%)	Al ₂ O ₃ (%)	CaCO ₃ (%)
1	5.83	0.36	0.29	8.29	10.20	25.20	64.60	1.80	3.10	0.12
2	5.14	0.16	0.19	9.13	19.00	22.80	58.20	1.60	3.20	0.29
3	4.92	0.19	0.46	7.65	17.00	20.50	60.50	1.80	2.90	0.32
4	4.81	0.16	0.38	8.05	20.00	21.00	59.00	3.90	3.50	0.29
5	5.11	0.21	0.62	8.65	19.00	18.60	62.20	1.60	4.60	0.18
6	4.53	0.21	0.29	10.11	16.20	26.20	57.60	1.60	4.20	Nil
7	6.65	0.12	0.50	6.53	18.80	21.00	59.20	1.50	3.90	0.21
8	6.42	0.08	0.28	10.92	14.20	24.60	62.20	1.80	3.80	0.16
9	5.39	0.28	0.93	11.00	23.90	20.90	56.20	1.90	4.00	0.20
10	4.93	0.13	0.48	10.11	17.00	20.40	61.70	2.10	3.60	Nil
11	4.92	0.17	1.14	10.50	14.50	20.40	65.10	2.30	3.80	Nil
12	4.72	0.11	0.75	9.80	23.00	21.60	56.40	2.10	4.10	0.23
13	6.96	0.16	0.46	7.50	12.40	26.20	61.40	2.60	4.50	0.14
14	6.32	0.21	0.93	6.48	12.80	19.10	68.10	1.90	3.90	0.19
15	6.16	0.17	0.68	12.32	15.60	21.40	63.00	2.00	3.60	0.31
16	6.84	0.09	0.66	15.65	17.40	22.70	59.90	2.10	4.10	0.35
17	6.03	0.40	0.62	10.11	18.50	22.30	59.20	2.20	4.50	0.36
18	4.92	0.19	0.71	9.92	15.50	32.80	51.70	2.10	3.90	0.12
19	4.65	0.21	0.84	9.11	13.40	26.80	59.80	2.10	4.30	Nil
20	6.34	0.34	1.03	9.02	12.60	22.90	64.50	2.00	4.20	Nil
Range	4.53-6.96	0.04-0.40	0.19-1.20	7.50-15.65	10.20-23.90	18.60-32.80	51.70-68.10	1.50-2.60	2.90-4.9	Nil-0.36
Mean		0.19	0.52	9.54	16.50	22.87	60.23	1.95	3.89	0.22

with a mean value of 1.95 per cent. The content of CaCO₃ varied from 0.00 to 0.36 per cent, with a mean value of 0.22 per cent.

Most of the soils are non-calcareous in nature. As far as their soil characteristics are concerned, there is no report available in the literature for soils of Dhanbad, Giridih and Hazaribagh districts. However, in case of soils from Ranchi, almost same ranges of these soil

characteristics have been reported by a few workers (Singh et al. 1993, Mahto et al., 1992).

Water Soluble Sulphur

The amount of water soluble sulphur varied from 3.75 to 28.15 mg kg⁻¹, with a mean value of 12.01 mg kg⁻¹. The water soluble sulphur was found positively and significantly correlated with EC ($r=0.229^*$) and CaCO₃ ($r=0.0305^*$). Electrical conductivity, CEC, clay and Fe₂O₃ could predict

Table 2. Different forms of sulphur (mg kg^{-1}) in surface soils of Jharkhand

Soil No.	Water soluble S	Sulphate S	Inorganic S (Adsorbed+Sulphate)	Organic S	Total S
1	7.67	17.75	33.00	292.00	325.00
2	15.75	21.00	61.50	248.50	310.00
3	4.45	23.25	55.25	221.75	277.00
4	28.15	26.50	78.25	186.25	264.50
5	7.75	24.50	52.00	261.00	313.00
6	8.75	25.00	71.00	321.00	392.00
7	4.50	15.75	74.00	271.00	345.00
8	8.50	14.25	63.00	215.00	278.00
9	12.00	14.60	41.00	319.00	360.00
10	18.00	13.00	50.00	273.00	323.00
11	17.00	14.50	44.50	382.50	427.00
12	11.51	23.00	35.50	263.00	294.00
13	17.75	20.50	62.00	245.00	307.00
14	6.00	17.50	39.00	373.00	412.00
15	17.00	19.25	44.50	317.50	362.00
16	3.75	16.50	31.00	263.00	294.00
17	19.00	22.50	81.50	363.50	445.00
18	10.75	17.25	61.50	350.50	412.00
19	5.25	13.75	47.00	114.00	161.00
20	17.00	25.00	53.50	291.50	345.00
Range	3.75-28.15	13.00-26.50	31.00-81.00	114.00-382.50	161.00-445.00
Mean	12.01	19.10	53.95	278.60	332.32

only about 49 per cent of variation in water soluble sulphur (Table 5). These findings are in conformity with the results reported by Aulakh and Dev (1976). The water soluble sulphur was significantly and positively correlated with sulphate sulphur ($r=0.916^{**}$), inorganic sulphur ($r=0.676^{**}$) and total sulphur ($r=0.773^{**}$). The significant and positive correlation of water soluble sulphur with sulphate sulphur has been reported by Ram et al. (1993) and Gowrisankar and Shukla (1999), while a positive correlation

of water soluble sulphur with total sulphur has been reported by Pandey et al. (1989).

Sulphate Sulphur

The amount of sulphate sulphur in the soils of Jharkhand ranged from 13.00 to 26.50 mg kg^{-1} , with a mean value of 19.10 mg kg^{-1} . This form of S was significantly and positively correlated with EC ($r=0.267^*$) and CaCO_3 ($r=0.413^{**}$). It indicates that with increase in EC and CaCO_3 content, the concentration of sulphate sulphur is also likely

Table 3. Correlation coefficient between form of S and soil properties

Forms of S	pH	EC	OC	CEC	Sand	Silt	Clay	Fe ₂ O ₃	Al ₂ O ₃	CaCO
Water soluble S	-0.073	0.299*	-0.071	0.093	-0.042	-0.105	0.168	0.201	0.082	0.305
Sulphate S	-0.176	0.267*	-0.218	-0.234	-0.092	-0.117	0.185	-0.226	0.095	0.413
Inorganic S	-0.042	0.066	0.428**	-0.342	-0.349	0.169	0.133	-0.212	0.128	0.204
Organic S	0.145	0.339*	0.371*	0.115	0.127	-0.082	0.034	0.453**	0.095	0.152
Total S	0.138	0.358*	0.275	0.371*	0.059	-0.042	0.011	0.355*	0.124	-0.21

Table 4. Correlation coefficient among different forms of sulphur

Forms of S	Water soluble S	Sulphate S	Inorganic S	Organic S	Total S
Water soluble S					
Sulphate S	0.916**				
Inorganic S	0.676**	0.375			
Organic S	-0.591	-0.588	-0.583		
Total S	0.773**	0.689**	0.599*	0.973**	

Table 5. Effect of soil characteristics on predictability of different forms of S in Jharkhand soils

Forms of sulphur	Regression equation	R ² × 100
Water soluble S	y = 10.665 + 23.874x ₂ + 9.579x ₈	31.60*
	y = 28.536 + 29.848x ₂ + 0.729x ₇ + 11.938x ₈	40.60*
	y = -33.93 + 36.293x ₂ + 9.20x ₃ + 0.835x ₇ + 16.079x ₈	49.00*
Sulphate S	y = 23.319 - 0.631x ₄ + 13.839x ₁₀	27.30
	y = 30.492 - 1.4x ₁ - 0.618x ₄ + 13.839x ₁₀	39.00*
	y = 22.481 - 1.842x ₁ - 0.706x ₄ + 2.788x ₉ + 17.104x ₁₀	42.00*
Inorganic S	y = 30.132 - 31.153 + 10.992x ₉	53.00*
	y = 47.641 - 29.44x ₃ - 2.291x ₄ + 11.89x ₉	61.00*
	y = 121.239 - 24.820x ₃ - 2.074x ₄ - 1.094x ₅ + 10.263x ₉	69.00*
Organic S	y = 189.843 + 208.52x ₂ + 77.736x ₃	39.00*
	y = 126.914 + 11.339x ₁ + 207.901x ₂ + 77.380x ₃	41.00*
	y = 92.812 + 10.468x ₁ + 230.091x ₂ + 71.938x ₃ + 3.973x ₄	51.00*
Total S	y = 253.635 + 239.348x ₂ + 51.338x ₃	49.00**
	y = 192.892 + 10.946x ₁ + 238.75x ₂ + 50.994x ₃	57.00**
	y = 284.614 + 14.33x ₁ + 247.5x ₂ + 55.749x ₃ + 1.905x ₇	69.00**

(Where, x₁, x₂, x₃, x₄, x₅, x₆, x₇, x₈, x₉, x₁₀ are pH, EC, CEC, OC, sand, silt, clay, Fe₂O₃, Al₂O₃, CaCO₃, respectively)

to increase which is in conformity with the results of Aulakh and Dev (1976), Pandey et al. (1989) and Gowrisankar and Shukla (1999). The sulphate sulphur corrected significantly and positively with total sulphur (Table 4). Ram et al. (1993) have also reported significant and positive association of sulphate sulphur with total sulphur. However, about 42 per cent variation in sulphate sulphur content could be explained on inclusion of pH, organic carbon, Al_2O_3 and CaCO_3 content (Table 5).

Inorganic Sulphur

The content of inorganic sulphur was found to vary from 31.00 to 81.50, being lowest in the soil from BAU forest of Ranchi (31.00 mg kg⁻¹) and highest in the soil from BAU farm, Ranchi (81.50 mg kg⁻¹). This form of sulphur was found significantly and positively correlated with organic carbon ($r=0.428^{**}$). The results of stepwise multiple regression analysis (Table 5) indicate that the inclusion of CEC, OC, sand and Al_2O_3 accounted for 69 per cent variation in inorganic S. The inorganic S was positively and significantly correlated with water soluble S ($r=0.676^{**}$) and total S ($r=0.599^{**}$).

Organics Sulphur

Though little is known about the nature of organics S compounds present in soil, its importance in respect to sulphur availability is well known. In absence of inorganic sulphur addition, this form of sulphur contributes to the available sulphur pools. The soils of Jharkhand were found to contain, on an average, 278.60 mg kg⁻¹ of organic sulphur (Table 2). It ranged from 114.00 (in an Ultisol from Hazaribagh) to 382.50 mg kg⁻¹ (in an Alfisol from Ranchi). The higher organic sulphur in this particular soil may be attributed to the highest organic carbon content (1.40%) among twenty soils used for this study. The organic sulphur content of soils of Jharkhand accounted for about 83 per cent of the total sulphur content. Reddy et al. (1985) have also reported that the contribution of organic sulphur

towards total sulphur was about 89 per cent in the alluvial soils of Andhra Pradesh. The results of present study emphasized that most of the sulphur present in these soils was in the form of organic sulphur. Similar findings have also been reported by Takkar (1986) and Singh et al. (1989).

Correlation studies (Table 4) indicate the significant and positive correlation of organic sulphur with EC ($r=0.339^*$), organic carbon ($r=0.371^*$) and Fe_2O_3 ($r=0.453^{**}$). These results are in conformity with earlier reports published by other workers (Mishra et al. 1990; Kher and Singh, 1993; Tripathi et al. 1997; Gowrisankar and Shukla, 1999). A highly significant and positive correlation between organic sulphur and organic carbon has also been reported by Rakesh Kumar et al. (2002) in acidic soils of Jharkhand. The combined effect of pH, EC, CEC and OC content of the soils accounted for about 51 per cent variation in organics sulphur content (Table 5). The organics sulphur correlated significantly with total sulphur ($r=0.973^{**}$).

Total Sulphur

The total sulphur content in the soils of four districts of Jharkhand was found to vary from 161.00 to 445.00 mg kg⁻¹, with an average value of 332.32-mg kg⁻¹. The total sulphur content was significantly and positively correlated with EC ($r=0.358^{**}$), CEC ($r=0.371^*$) and Fe_2O_3 content ($r=0.355^{**}$). the significant and positive correlation of total sulphur with EC has also been reported by Pandey et al. 1989, Ram et al. 1993, Singh et al. 1993, Tripathi et al. 1997 and Gowrisankar and Shukla, 1999).

The electrical conductivity along with CEC accounted for 49.00 per cent variation in total sulphur content, which is evident from results of stepwise multiple regression analysis (Table 5). Inclusion of pH improved the prediction to 57.00 per cent and further inclusion of clay as another variable improved the prediction to 69.00 per cent.

REFERENCES

- Aulakh, M.S. and Dev, G. 1976. *J. Indian Soc. Soil Sci.*, 24 : 308-313.
- Butters, B. and Chenery, E.M. 1959. *Analyst* 84 : 2890 (C.F. Hesse, P.R., ed.), A Textbook of Soil Chemical

- Analysis, Chemical Publishing Co., New York, pp. 301-331.
- Chesnin, L. and Yien, C.H. 1951. *Proc. Soil Sci. Soc. Am.*, **15** : 149-151.
- Donahue, R.L., Miler, R.W. and Shikluna, J.C. 1977. Soils. In : An Introduction of Soil and Plant Growth University of Wisconsin, Madison.
- Fox, R.L., Olson, R.A and Rhoades, H.F. (1964). *Proc. Soil Sci. Soc. Am.*, **28** : 243-246.
- Gowrisankar, D. and Shukla, L.M. 1999. *Commun. Soil Sci. Pl. Anal.*, **30** : 2643-2654.
- Kher, D and Singh, N. 1993. *J. Indian Soc. Soil Sci.*, **41** : 164-165.
- Mahto, S.N., Singh, K.P. and Singh S. 1992. *J. Indian Soc. Soil Sci.*, **40** : 846-847.
- Mishra, U.K., Das, C.P. and Mitra, G.N. 1990. *J. Indian Soc. Soil.*, **38** : 61-69.
- Pandey, D.K, Tiwari, K.N. and Tiwari, R.C. 1989. *J. Indian Soc. Soil Sci.*, **37** : 161-163.
- Rakesh Kumar, Singh, K.P. and Singh, Surendra 2002. *J. Indian Soc. Soil Sci.*, vol. 5U No. 3 pp. 502-505.
- Ram, H., Dixit, V.K. and Khan, T. 1993. *J. Indian Soc. Soil Sci.*, **41** : 564-565.
- Reddy, A.T. Rao, A.S. and Subba, Rao, I.V. 1985. *J. Indian Soc. Soil Sci.*, **33** : 416-418.
- Singh, A.L., Joshi, V.C. Dayal, D. and Misra, J.B. 1989. In : Proceedings National Seminar on Sulphur in Agriculture, Bangalore, 76-81.
- Singh, S., Singh, K.P., Rana, N.K. and Sarkar, A.K. 1993. *J. Indian Soc. Soil Sci.*, **41** : 562-563.
- Takkar, P.N. 1986. Proc. BARC-TSI Int. Symp. Sulphur in Agricultural Soils, Dhaka, pp. 299-350.
- Tripathi, R.K., Singh K. and Karwasra, S.P.S. 1997. *J. Indian Soc. Soil Sci.*, **45** : 386-388.
- Williams, C.H. and Steinbergs, A. 1959. *Aust. J. Agric Res.* **1C** : 840-852.

INFLUENCE OF COMPONENTS OF INM ON FRUIT YIELD AND QUALITY OF ACID LIME IN RED CALCAREOUS SOIL

M.A. AARIFF KHAN, HAMEEDUNNISA BEGUM AND G. SWARAJYALAKSHMI

*Acharya N.G. Ranga Agricultural University
Citrus Research Station, Petlur, Venkatagiri-- 524132, A.P.*

ABSTRACT

The fruit yield of acid lime was significantly and positively influenced by the application of iron pyrites (IP), pressmud (PM), FYM and VAM either individually or combinedly over control in both first and second year. Among the treatments, integrated use of iron pyrites @ 200g/plant along with FYM 25 kg + PM 2 kg/plant was out yielded in both direct and cumulative effect was found to be the best treatment. The total soluble solids (TSS) was not significant by the direct effect treatments, while the cumulative effect treatments of second year was significantly responded. Acidity was increased significantly by different treatments in direct and cumulative effect over control. The highest acidity was recorded by the individual higher dose of FYM @ 50 kg/plant at 18 and 24 months period of cumulative effect, whereas the combined application of FYM 25kg + PM 2kg + IP 200g/plant was recorded the highest acidity at 12 months period of direct effect.

Key words : Acid lime, nutrient management, calcareous soil, yield, quality.

In Andhra Pradesh acid lime is one of the important commercial citrus species grown in arid and semiarid areas of Nellore and Rayalaseema regions. Soil suitability is a must for successful acid lime cultivation. Unfortunately most of the acid lime orchards in different districts of Andhra Pradesh was under both red and black calcareous soils, which needs special attention in major and micro nutrition otherwise the longevity of orchards is reduced (CRS, 1999). In order to achieve an intensive production of citrus fruits with good quality in calcareous soils, it is necessary to follow simultaneously all the practices through integrated nutrient management (INM) to sustain the productivity and to improve the fertility (Gurbachan Singh *et al.*, 1999).

MATERIALS AND METHODS

The experiment was laid out in randomized block design with three replications and 4 trees as treatment unit on 3 years young plants of acid lime at Citrus Research Station, Petlur of the Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soil samples at 0-30, 30-60 and 60-90 cm depth were collected, air dried and pounded.

Soil pH and electrical conductivity was determined in 1:2.5 soil water suspension with combined glass electrode pH meter, solubridge conductivity meter and available N, P, K, S status analyzed according to standard procedures described by Jackson (1973). The organic carbon content by wet digestion method (Walkley and Black, 1934) and free CaCO₃ by rapid titration method (Piper, 1966). Available micronutrient cations were extracted with DTPA (Lindsay and Norwell, 1978) and estimated with an atomic absorption spectrometer Model 170-30. Hitachi, Japan.

The 19 treatments consisted of two sources of organic manures viz., FYM and pressmud (PM) at levels each (25, 50 kg and 4, 8 kg/plant). Source of inorganic material as agricultural grade iron pyrites (IP) at three levels (100, 200 and 300 g/plant) and biofertilizer, VAM at 150 g/plant were applied through soil application during rabi seasons of 1997-98 as first and 1998-99 as second year by individually and combinedly.

The observations on fruit yield (kg/plant). TSS. and acidity were recorded at 6 months regular interval during first and second year. After the planting of seedlings the first crop was

harvested at the end of first year experiment. Mature fruits were harvested in 3-4 pickings during two main seasons of the year i.e., October/November and April/May. Fully ripened fresh fruits were collected at random from each treatment, washed in distilled water. The TSS content was directly read with the help of Erma, Japan model hand refractometer (range 0-32%) and the results obtained were corrected at 20°C with the help of temperature correction table AOAC, 1980). The acidity in fruit juice was estimated by adopting the procedure described by Ranganna (1986). The data were statistically analyzed according to the procedure suggested by Fisher (1948).

RESULTS AND DISCUSSION

Fruit yield

The perusal of data (Table 1) revealed that application of higher dose of individual IP, FYM and PM (T₄, T₆ and T₈) and combined application of iron pyrites (IP) @ 200 g/plant along with FYM 25 kg/plant (T₉), PM 4 kg/plant (T₁₁) and FYM 25 kg + PM 2kg/plant (T₁₆) had significant effect on fruit yield over control by direct and cumulative effect. Lower doses of IP and VAM alone (T₂, T₃ and T₁₇) and combination of biofertilizer (VAM) along with IP @ 100 g/plant (T₁₈) are not significantly effected. Among the treatments conducive use of iron pyrites @ 200 g/plant with FYM 25 kg + PM 2 kg (T₁₆) was found to be best combination treatment compared to individual higher doses of IP (T₄), FYM (T₆) and PM (T₈) during first and second

Table 1. Fruit yield (kg/plant) of acid lime as influence by INM

Tr. No.	Treatments	First year (1997-98)	Second year (1998-99)	
		Direct effect	Cumulative effect	
		12 months	18 months	24 months
T ₁	Control	3.63	3.82	4.17
T ₂	Iron Pyrites (IP) 100 g/plant	3.95	4.25	4.89
T ₃	Iron Pyrites (IP) 200 g/plant	4.20	4.64	5.32
T ₄	Iron Pyrites (IP) 300 g/plant	4.70	5.10	5.88
T ₅	FYM 25 kg/plant	4.93	5.20	6.10
T ₆	FYM 50 kg/plant	5.84	6.60	7.75
T ₇	Pressmud (PM) 4 kg/plant	4.79	5.04	5.90
T ₈	Pressmud (PM) 8 kg/plant	5.71	6.37	7.56
T ₉	FYM 25 kg + IP 100g/plant	5.29	5.61	6.72
T ₁₀	FYM 25 kg + IP 200g/plant	5.73	6.26	7.54
T ₁₁	PM 4 kg + IP 100g/plant	5.06	5.38	6.30
T ₁₂	PM 4 kg + IP 200g/plant	5.40	5.85	6.86
T ₁₃	FYM 12.5 kg + PM2 kg + IP 100g/plant	4.55	4.91	5.87
T ₁₄	FYM 12.5 kg + PM2 kg + IP 200g/plant	5.14	5.50	6.65
T ₁₅	FYM 25 kg + PM2 kg + IP 100g/plant	5.51	6.19	7.30
T ₁₆	FYM 25 kg + PM 2 kg + IP 200g/plant	6.06	6.93	7.98
T ₁₇	VAM alone 150g/plant	3.82	4.15	4.71
T ₁₈	VAM + IP 100g/plant	4.16	4.43	5.10
T ₁₉	VAM + IP 200g/plant	4.50	4.99	5.65
	C.D. (0.05)	0.83	0.89	1.06

year duration. This may be attributed to the better increased availability and uptake of nutrients throughout the period of crop growth as well as prevailing better physical, chemical and biological properties of soil. The yield was increased by 66.9 and 91.4 per cent over control by direct and cumulative effect treatments, respectively. Combined applications performed better than individual application of IP, FYM and PM. Because of wider C : N ratio of manures, mineralization occurred slowly and the supply of nutrients in the early stages of crop growth was delayed. These findings are in conformity with the results of Tiwari *et al.*, (1999) and Uma Reddy (1999). Among the individual sources organic manures (FYM and PM) produced higher fruit yield than inorganic iron pyrites and

biofertilizer (VAM) and the order followed was FYM (T₆) > PM (T₈) > IP (T₄) > VAM (T₁₇) > control (T₁). the results further showed that fruit yield was also influenced by the integrated use of iron pyrites @ 200 g/plant with VAM (T₁₉) compared to VAM alone (T₁₇). It clearly indicate the beneficial effect of VAM infection to citrus roots and mycorrhizal dependency of acid lime (IIHR News, 1992).

Quality parameters

Data presented in Table 2 indicated that the application of different organic manures, iron pyrites and VAM either alone or in-combinations by direct effect treatments did not influence TSS significantly during first year. However, during second year at both 18 and 24 months period

Table 2. Total soluble solids (%) in fruits of acid lime as influence by INM

Tr. No.	Treatments	First year (1997-98)	Second year (1998-99)	
		Direct effect	Cumulative effect	
		12 months	18 months	24 months
T ₁	Control	7.03	7.03	7.07
T ₂	Iron Pyrites (IP) 100 g/plant	7.07	7.10	7.17
T ₃	Iron Pyrites (IP) 200 g/plant	7.10	7.17	7.23
T ₄	Iron Pyrites (IP) 300 g/plant	7.17	7.20	7.27
T ₅	FYM 25 kg/plant	7.23	7.27	7.34
T ₆	FYM 50 kg/plant	7.35	7.47	7.52
T ₇	Pressmud (PM) 4 kg/plant	7.17	7.23	7.30
T ₈	Pressmud (PM) 8 kg/plant	7.27	7.40	7.47
T ₉	FYM 25 kg + IP 100g/plant	7.27	7.40	7.47
T ₁₀	FYM 25 kg + IP 200g/plant	7.30	7.40	7.50
T ₁₁	PM 4 kg + IP 100g/plant	7.17	7.23	7.34
T ₁₂	PM 4 kg + IP 200g/plant	7.23	7.30	7.36
T ₁₃	FYM 12.5 kg + PM2 kg + IP 100g/plant	7.20	7.27	7.37
T ₁₄	FYM 12.5 kg + PM2 kg + IP 200g/plant	7.27	7.30	7.43
T ₁₅	FYM 25 kg + PM2 kg + IP 100g/plant	7.33	7.37	7.40
T ₁₆	FYM 25 kg + PM 2 kg + IP 200g/plant	7.37	7.43	7.50
T ₁₇	VAM alone 150g/plant	7.03	7.07	7.70
T ₁₈	VAM + IP 100g/plant	7.07	7.13	7.17
T ₁₉	VAM + IP 200g/plant	7.13	7.20	0.27
	C.D. (0.05)	NS	0.26	0.27

the TSS was significantly differed by the cumulative effect over control. The highest TSS (7.47 and 7.52%) was recorded where the individual higher dose of FYM @ 50 kg/plant (T6) was applied followed by the combined application of FYM 25 kg + PM 2 kg + IP 200 g/plant (T16). the higher TSS might be due to the improvement in metabolic and enzymatic activity during fruit formation and maturity, which might have triggered the processes related to quality as reported by Sharma and Reddy (1986) and Aariff Khan (2001).

Acidity

Perusal of data in Table 3 indicate acidity in fresh fruit juice was significantly effected by type and level of manure and fertilizer over control

by both direct and cumulative effect treatments. The highest acidity was observed by T₁₆ (FYM 25 kg + PM 2 kg + IP 200 g/plant) at 12 and 18 months (7.14 and 7.20%) and by T₆ (FYM @ 50 kg/plant) at 24 months period of cumulative effect (7.36%). The acidity at 12, 18 and 24 months duration in individual higher doses followed the order : FYM > PM > IP, while in case of combination treatments T₁₆ (FYM 25kg + PM2kg + IP200g/plant) > T₁₀ (FYM 25 kg + IP 200 g/plant) > T₁₅ (FYM 25 kg + PM 2 kg + IP 100 g/plant > T₁₂ (PM 4 kg + IP 200 g/plant). The high content of acidity in fruit juice was resulted due to application of individual FYM @ 50 kg/plant and combined and maximum recovery of plants from iron chlorosis deficiency and also

Table 3. Acidity (%) in fruits of acid lime as influence by INM

Tr. No.	Treatments	First year (1997-98)	Second year (1998-99)	
		Direct effect	Cumulative effect	
		12 months	18 months	24 months
T ₁	Control	6.80	6.83	6.85
T ₂	Iron Pyrites (IP) 100 g/plant	6.84	6.88	6.93
T ₃	Iron Pyrites (IP) 200 g/plant	6.93	6.96	7.03
T ₄	Iron Pyrites (IP) 300 g/plant	6.97	7.09	7.10
T ₅	FYM 25 kg/plant	7.01	7.15	7.20
T ₆	FYM 50 kg/plant	7.12	7.26	7.36
T ₇	Pressmud (PM) 4 kg/plant	6.99	7.11	7.18
T ₈	Pressmud (PM) 8 kg/plant	7.08	7.26	7.32
T ₉	FYM 25 kg + IP 100g/plant	7.06	7.17	7.27
T ₁₀	FYM 25 kg + IP 200g/plant	7.12	7.24	7.33
T ₁₁	PM 4 kg + IP 100g/plant	7.03	7.14	7.21
T ₁₂	PM 4 kg + IP 200g/plant	7.04	7.18	7.26
T ₁₃	FYM 12.5 kg + PM2 kg + IP 100g/plant	6.99	7.12	7.17
T ₁₄	FYM 12.5 kg + PM2 kg + IP 200g/plant	7.03	7.18	7.25
T ₁₅	FYM 25 kg + PM2 kg + IP 100g/plant	7.10	7.23	7.28
T ₁₆	FYM 25 kg + PM 2 kg + IP 200g/plant	7.14	7.28	7.33
T ₁₇	VAM alone 150g/plant	6.85	6.90	6.94
T ₁₈	VAM + IP 100g/plant	6.91	6.99	7.06
T ₁₉	VAM + IP 200g/plant	6.96	7.10	7.13
	C.D. (0.05)	0.18	0.10	0.12

emphasized that nutrient deficiency reduced the quality of citrus fruits in calcareous soils. The findings are in agreement with those of Hu (1986) and Aariff Khan *et al.*, (1999).

It is concluded that the integrated use of

iron pyrites @ 200 g/plant along with FYM 25 kg + PM 2 kg was found to be the best in influencing the optimum fruit field, TSS and acidity in acid lime under calcareous soils as compared to individual application application of higher dose of FYM and PM.

REFERENCES

- Aariff Khan, M.A. 2001. Nutrient status - Integrated Nutrient Management in Acid line (*Citrus aurantifolia*, Swingle) orchards grown on red calcareous soils of Nellore District. Ph. D. thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.
- Aariff Khan, M.A., hameedunnisa Begum, Chenchu Reddy, B. and Govinda Rajulu, B. 1999. Correction of lime induced iron chlorosis in acid lime (*Citrus aurantifolia*, Swingle) in calcareous Alfisols. Abstracts : In International Symposium on Citriculture. National Research Centre for Citrus, Nagpur. Nov. 23 - 27, pp. 83-84.
- Association of Official Agricultural Chemists (AOAC) 1980. Official and Tentative methods of Analysis, Washington DC.
- Citrus Research Station (CRS) 1999-2000. Annual Report, Petlur, ANGRAU, pp. : 14-24.
- Fisher, R.A. 1948 Statistical Methods for Research workers - Halnew publishers company Incorporation, New York.
- Gurbachan Singh, Soni, M.L., Singh, S.K. and Singh, N.T. 1999. J. Indian Soc. Soil Sci., 47 : 345.
- Hu, D.Y. 1986. *Soils*, 17 : 20.
- Indian Institute of Horticulture Research News (IIHR News). 1992. Integrated nutrient management in Horticulture crops. *Indian Institute of Horticultural Research News*, 13 : 1.
- Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private limited, New Delhi.
- Piper, C.S. 1966. Soil and Plant Analysis. Hans publishers, Bombay. pp. : 137.
- Ranaganna, S. 1986. Handbook of Analysis and quality control of fruit and vegetable products. Tata Macgraw - Hill publishing company Limited, New Delhi. pp. 881.
- Sharma, P.S. and Reddy, P.V. 1986. *India J. Agri. Sci.*, 56 : 423.
- Tiwari, U.S., Pujari, C.V. Jagtap, D.O. and Rajadhv, S.B. 1999. Effect of organic and inorganic fertilizers on yield and quality of sweet orange (*Citrus sinensis*). Hi Tech Citrus Management. Proceedings of International symposium on Citriculture, Nov. 23 - 27, 1999. National Research Centre for Citrus, Nagpur. pp. : 389.
- Uma Reddy, R. 1999. Integrated nutrient management in tomato - onion cropping system. Ph. D. Thesis. Acharya N.G. Ranga Agricultural University, Hyderabad.
- Walkley, A. and Black, C.A. 1934. An examination of degtjaraff method for determining soil organic matter and proposed modification for the chromic acid titration method. *Soil Science*, 37 : 29.

INTEGRATED USE OF CGA245704 AND *TRICHODERMA HARZIANUM* ON DOWNY MILDEW SUPPRESSION AND ENZYMATIC ACTIVITY IN CAULIFLOWER

PRATIBHA SHARMA, S.K. SAIN, M. SINDHU AND L.N. KADU

Division of Plant Pathology
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Downy mildew disease management is a major priority in cauliflower crop system. To develop a safe and ecofriendly plant protection strategy, CGA245704 (Bion), a chemical activator (abiotic elicitor), *Trichoderma harzianum*, a biological elicitor as seed treatment, seedling dip and foliar application were used to induce systemic resistance on a susceptible variety Himjyoti of cauliflower. Induced resistance was recorded in the form of reduction in disease severity index ranging 0.52 - 1.25 of Bion (SD + SL + FL) and Th (SD + SL) + Bion (FL) treated plants as compared to 4.53 of control up to 72 days after sowing. Changes in Phenylalanine ammonia lyase and peroxidase activities in the CGA 245704 and *Trichoderma harzianum* treated plants also highlight the metabolic changes in the plant system along with the reduction in disease severity index.

Key words : Induced resistance, downy mildew, cauliflower, phenylalanine ammonia lyase, peroxidase, disease infection index.

Downy mildew caused by *Peronospora parasitica* (Pers. ex. Fr.) Fr., is a most threatening disease of cauliflower (*Brassica oleracea* var. capitata), causes economically significant losses in area of the world where persistent cool damp weather, high humidity and air movement favour sporulation, dissemination and infection by the causal fungus. At present, the common disease management options are the application of fungicides and the use of cultivars with resistance based on single genes. The disadvantages associated with both these measures have provided an incentive to develop more economical, environmentally sound and reliable methods of disease control. To this end, much research effort is being channeled towards accentuating natural disease resistance under the control of complex physiological, biochemical and genetic processes, which are not vulnerable to erosion, by change in pathogen virulence.

Many factors like prior pathogen attack and various chemical and environmental stimuli have been reported to induce high levels of systemic induced resistance (ISR) to subsequent pathogen attack. This ISR is associated with gene induction, the activation of a wide range of

disease resistance mechanisms and the production of a wide range of defence compounds, which is race non-specific and is effective against a broad spectrum of pathogenic agents (Kuc, 1995). Not only chemical but also certain biocontrol agents such as *Trichoderma viride* has been reported to act as a biotic elicitor probably due to their capacity to induce defence reaction in the host (Lughtenburg *et al.*, (1991).

Therefore, present investigation was carried out to understand the use of single and mixed combination of abiotic and biotic elicitors in inducing disease resistance and resistance related enzymes, which can be an effective part of Integrated Pest Management schedule.

MATERIALS AND METHODS

During the period of November 2001 to March 2002 and November 2002 to March 2003 two consecutive experiments were conducted under glasshouse conditions and in the fields of IARI, New Delhi. A highly susceptible variety to downy mildew 'Pusa Himjyoti' of cauliflower (*Brassica oleracea* var capitata) was used as a test host throughout the experiments. Treated

seedlings were raised in 6" plastic pots with a mixture of FYM, soil and sand (in 1:1:1 ratio). The seedlings were raised under glasshouse conditions. Seven-day-old seedlings were inoculated with a conidial suspension of *Peronospora parasitica* (2×10^4 conidia ml⁻¹) with the help of micro-syringe. Plants were inoculated with conidial suspension (2×10^4 conidia ml⁻¹) with the help of haemocytometer prepared by harvesting sporangia from incubated cauliflower leaves/infected with the fungus (Bains and Jhoo, 1976). Seed of cauliflower were imbibed for 24 h in a suspension of CGA 245704 (Bion) made up in sterile distilled water (SDW) followed by drying seed were then air dried on filter paper at room temperature for 24 h prior to sowing. The seedling dip and foliar spray followed by seed treatment were done by using recommended concentration. *T. harzianum*, (a sorghum based Laboratory preparation, of *T. harzianum* 2×10^6 cfu/g) applied at the rate of 4 gm litre⁻¹. the seedling dip treatment was given at 28 (at transplanting stage) days after sowing (DAS) by dipping in solutions for 30 minutes whereas, foliar spray was performed on 10 days after transplanting (38 DAS). Development of Downy mildew of cauliflower was assessed by two parameters i.e. Disease Intensity and Diseases infection index at an interval of 12, 24, 36, 48, 60 and 72 days after sowing (DAS).

Combination of CGA245704 and T. harzianum

Following four combination of the CGA 245704 and *T. harzianum* was used throughout the experiment for seed treatment (SD), seedling/transplanting dip (SL) at 28 DAS and foliar spray (FL) at 38 DAS. viz. Th (SD+SL+FL), Bion (SD+SL+FL), Th (SD+SL) + Bion (FL), and Bion (SD+SL)+Th(FL).

Assessment of disease severity downy mildew on cauliflower

All the plants from each treatment scored following 0-5 scale, Where 0 = no disease, 1 = 1-5% damage of leaf area, 2 = 6-15% damage of leaf area, 3 = 16 - 25% damage, 4 = 26-50% damage, and 5 = 51 or more damage.

Phenylalanine ammonia lyase and total soluble peroxidase assays

Subsamples of planting material were

collected at an interval of 0, 7, 14, 21, 28, 35 and 42 days after inoculation of conidia of *Peronospora parasitica* from cauliflower plants. SDW-treated plant samples were sampled at the same time served as control. For each treatment, a 2g sample was homogenized in 20 ml of homogenization buffer (0.1 M potassium phosphate, 50mM sodium metabisulphite, 1 mM phenyl methyl sulphonyl fluoride, and 250 mM source, pH 7.0). The homogenate was mixed with 2.5 g of polyvinyl polypyrrolidone (standard grade, sigma Chemicals Co., St. Louis) and 1.25 g of Amberlite XAD-4 (standard grade, sigma) ion exchange resin for 2 min, filtered through two layers of muSLin cloth, and centrifuged at $100,000 \times g$ at 4°C for 30 min. A 1-ml aliquot of supernatant was purified further and desalted by centrifugation through a 2 ml Sephadex (G25 mini-column (3,000 rpm for 5 min at 4°C). the G25 column removes excess salt and simple organic acids that might interfere with both the phenylalanine ammonia-lyase and total soluble peroxidase assays (Koukal and Conn, 1961). For PAL, 50 ml of supernatant was mixed with 950 ml of substrate buffer (10 mM L-phenyl alanine in 100mM potassium borate, pH 8.8) and the formation of t-cinnamic acid was measured at 290 nm after 2h of incubation at 30°C. PAL activity was expressed as nanomoles of t-cinnamic acid per gram fresh weight per hour. For peroxidase, 50 ml of supernatant was mixed with 950 ml of substrate buffer [4.5 mM guaiacol (50 ml)], 2. 2mM hydrogen peroxide, and 200 mM potassium phosphate, pH 5.8) (Reuveni and Perl, 1979). The formation of tetraguaiacol was recorded spectrophotically at 470 nm for 2 min, and a rate was determined. Peroxidase activity was expressed as nanomoles tetraguaiacol per gram fresh weight per hour. Six assays for both Pal and peroxidase were performed for each sample.

RESULTS AND DISCUSSION

Effect of biotic and abiotic elicitors on infection index of downy mildew on cauliflower

Downy mildew severity was assessed on 0-5 scale at a regular interval of 12 days. Data presented in table 1 clearly shows that there is a significant difference in disease severity in each treatment at different days after sowing. Among

these the best results were shown by seed + seedling dip + foliar spray of Bion 50-mg L⁻¹ concentration where the disease severity was below 2 on 0-5 scale from 12 DAS to 72 DAS. However, there is no significance difference in case of Bion (SD+SL+FL) and Th (SD+SL)+Bion (FL). In case of Th (SD+SL+FL) disease severity was higher than that of Ridomil MZ and other treatment upto 48 DAS which reduced to 1.95 at 72 DAS. Comparison of five different treatments alone and in combination showed the maximum reduction of disease severity in case of Bion (SD+SL+FL) followed by Th (SD+SL) +Bion (FL) and Bion (SD+SL)+Th (FL). The reduction of disease severity is less in Th (SD+SL+FL) at 36 and 48 DAS than other treatments.

As in table 1 the disease severity was lesser in all treatments compared to control up to 72 DAS. The disease severity index was 0.58 to 1.85 in Bion (SD+SL+FL) up to 36 DAS but reduced 1.85 to 0.62 till last observation (72 DAS), which indicates that seedling dip at 28 DAS and foliar spray at 38 DAS sensitizing the plants for. While, the Ridomil MZ showed its reducing effect on disease severity for a lesser time after which the disease severity was increased up to 72 DAS.

Effect of application of biotic and abiotic elicitors on symptom expression due to downy mildew

In the present investigation an attempt was therefore, made to study the effect of sensitizing plants by using biotic and abiotic elicitors against *Peronospora parasitica* causing downy mildew of cauliflower. Hence, to carry out investigation, abiotic elicitor like Benzothiadiazole, benzo (1, 2, 3) thiadiazole-7-carbothioic acid S-methyl ester, CGA245704 (Bion, BTH; is taken as a abiotic elicitor and *T.harzianum*, a laboratory preparation of *Trichoderma harzianum* taken as biotic elicitor and Ridomil MZ, a (matalaxyl + mancozeb, 1:8) fungicide is taken as a fungicidal control to carry out the experiment.

The data presented in table 2 depicting that there is clear difference in susceptibility reactions (discolored patches <0.1 cm at 36 and 60 DAS was observed by Bion (SD+SL+FL) The as necrotic patches at 36 DAS was maximum in Th

(SD+SL)+Bion (FL) followed by Bion (SD+SL+FL) whereas, it was maximum in Bion (SD+SL+FL) at 60 DAS clearly indicates that induction of resistance was faster in Th (SD+SL)+Bion (FL) but lesser than Bion (SD+SL+FL) treatment at 30 DAS. The induced resistance (IR) activity at 60 DAS was greater and faster in Bion (SD+SL+FL) followed by Th (SD+SL)+Bion (FL) clearly indicates its long lasting IR response at 60 days after sowing clearly indicate that disease severity was low in case of Bion 50 mg and Ridomil MZ, which was considerably lower as compared preinoculation treatment.

Effect of treatments of biotic and abiotic elicitors on phenyl alanine ammonia lyase and peroxidase enzyme activity

PAL activities increased in inoculated control but at a slower rate than in other treatments. There is net and significant increase in PAL activity in plants, treated with Bion (SD+SL+FL) at a concentration of 50 mg L⁻¹ (Fig.1), while treatment with Th (SD+SL) +Bion (FL) showed increase in PAL activity but at a significantly lower than Bion (SD+SL+FL). PAL activities Ridomil MS, Bion (SD+SL)+Th (FL) and Th (SD+SL+FL) is higher than control. There has been significant difference in enzyme activities of Ridomil MZ and Th (SD+SL) + Bion (FL) the persistent increase in PAL activity was upto 18.33 and 29.32 per cent, respectively higher than in control while in Bion (SD+SL+FL) treated plants the increase was upto 32.52 per cent at 35 days after inoculation. The increase in PAL activity indicates activation of the phenyl propanoid often increases. In several host pathogen interaction, increased levels have been shown to be correlated with incompatibility (Bhattacharya and Ward, 1988). The product of PAL is trans-cinnamic Singh *et al.*, 1999 that is an immediate precursor for the biosynthesis of salicyclic acid, a signal molecule in SAR (Klessing and Malamy, 1994).

Levels of peroxidase activity in elicitors applied plants are shown in Fig. 2. The peroxidase activity was significantly higher in all treatments as compared to control. More than 50 per cent increase in peroxidase activity was

Table 1. Disease severity index of downy mildew due to treatment of biotic and abiotic elicitors

Treatment	Disease severity index (0-5 scale)					
	Days after sowing					
	12	24	36	48	60	72
Control	1.09	2.57	3.45	3.59	3.77	4.53
Ridomil MZ	1.50	1.60	2.59	2.11	2.42	2.71
Th (SD+SL+FL)	1.90	2.00	3.11	2.58	2.25	1.95
Bion. (SD+SL+FL)	0.58	0.71	1.85	1.25	1.09	0.62
Th (SD+SL)+Bion(FL)	0.90	1.11	2.17	1.85	1.77	0.95
Bio (SD+SL)+Th (FL)	1.50	1.70	2.38	2.45	2.34	1.25
CD (P=0.05)	0.41	0.45	0.31	0.67	0.73	0.34

Table 2. Effect of biotic and abiotic elicitors on symp to m expression pattern of cauliflower due to downy mildew in pathogen inoculated plants

Treatments	Symptom expression (in percentage)			
	Discolored patches		Necrotic patches	
	<0.1 cm	>0.1 cm	<0.1 cm	>0.1 cm
36 days of sowing				
Control	10.0	3.0	21.0	31.0
Ridomil MZ	30.5	35.5	24.8	10.2
Th (SD+SL+FL)	15.0	41.0	18.0	26.0
Bion. (SD+SL+FL)	68.0	7.0	18.0	7.0
Th (SD+SL)+Bion(FL)	41.0	18.0	28.0	13.0
Bio (SD+SL)+Th (FL)	28.0	31.0	18.0	26.0
60 days of sowing				
Control	11.0	43.0	6.0	40.0
Ridomil MZ	16.0	51.0	9.0	26.0
Th (SD+SL+FL)	20.0	37.0	12.0	31.0
Bion. (SD+SL+FL)	48.0	12.0	30.0	10.0
Th (SD+SL)+Bion(FL)	27.0	22.0	25.0	26.0
Bio (SD+SL)+Th (FL)	23.0	33.0	14.0	28.0

observed in Bion (SD+SL+FL) treated plants. There was significantly lower than Th (SD+SL)+Bion (FL). There is no significant increase in peroxidase activity of Ridomil MZ treated plants, but steady increase in peroxidase activity was observed in all treatments. Enhanced peroxidase activity very often is associated with resistance phenomena such as lignin production (Ride, 1975; Hammerschmidt and Kuc, 1982;

Reuveni *et al.*, 1991). *Trichoderma harzianum* is shown to induce peroxidase during hypersensitive like reaction of grapevine cells (Calderon *et al.*, 1994).

In the present investigation on seed treatments, seedling dip and foliar spray of Bion, reducing the disease severity of *Peronospora parasitica* on cotyledons, may be due its well

known property to induce resistance and inhibiting the mycelial development by triggering the various defence related pathways (Gorlach, 1996). It has been observed that the disease severity was highly reduced by Bion (SD+SL+FL) 50 mg L⁻¹ followed by Th (SD+SL)+Bion (FL) and Bion (SD+SL)+Th (FL). The least reduction in disease severity at 60 DAS was recorded in Ridomil MZ treated plants.

The results clearly indicates the systemic induction of resistance from cotyledons to first and second true levels of cauliflower till full expansion of leaves which are in concordance with those results reported by Sharma, 2002. Singh *et al.* (1999) reported systemic induction of resistance in *Brassica Juncea*, in first and second true leaves when inoculated with incompatible race of *Albugo candida*. In the present investigation systemic defence related enzymes

viz. PAL and peroxidase has shown the increasing trends in all the treated plants including untreated control plants. However, there has been significant increase of PAL activity in Bion (SD+SL+FL) followed by Th (SD+SL)+Bion (FL) and Bion (SD+SL)+Th (FL). The other treatments have show moderate increase. There is a positive correlation between disease resistance and increase in enzyme activities. Similar kinds of results were obtained in case of peroxidase activity in all the treated plants. This may happen because in post inoculated plants pathogen is already established and elicitors, which are not having any fungicidal properties (Gorlach, 1996). Therefore, the use of CGA 245704 and *T.harizianum* alone and in combination, which induce resistance in the plant system, can be ecofriendly and safe in IPM programmed in the cauliflower downy mildew management.

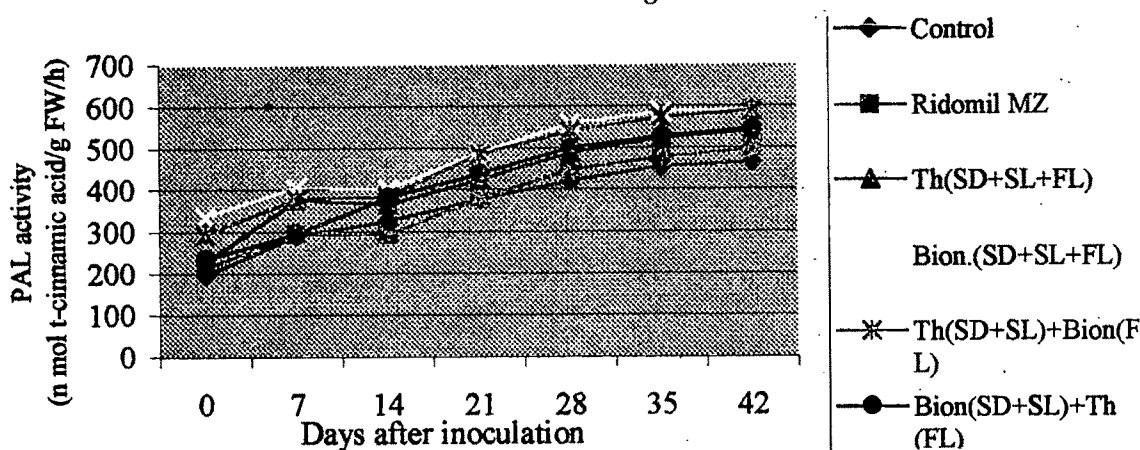


Fig. 1. PAL activity in biotic and abiotic elicitor treated plants (n mol t-cinnamic acid/gFW/H)

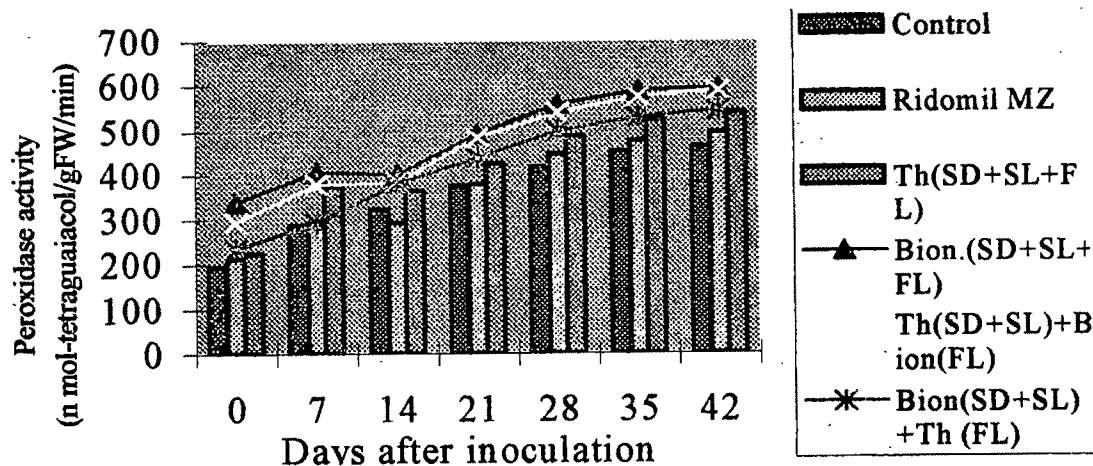


Fig. 2. Peroxidase activity in biotic and abiotic elicitor treated plants (n mol t-tetraguaiacol/gFW/min)

REFERENCES

- Bains, S.S., Sokhi, S.S. and Jhooty, J.S. 1981. Outbreak of *Peronospora parasitica* on cauliflower curd in Punjab. *Indian Phytopath.*, **34** : 389-390.
- Bhattacharya, M.K., Ward, E.W.B. 1988. Phenylalanine ammonia lyase activity in soybean hypocotyl and leaves following infection with *Phytophthora megasperma* f. sp. *glycinea*. *Can. J. Bot.*, **66** : 18-23.
- Calderon, A.A., Zapata, J.M., and Ros Barolo, A. 1994. Peroxidase-mediated formation of resveratrol oxidation products during the hypersensitive like reaction of grapevine cells to an elicitors from *Trichoderma harzianum*. *Physiol. Mol. Plant pathol.*, **44** : 289-299.
- Gorlach, J., Volrath, S., Khauf-Beiter, G., Hengy, G., Beckhove, U., Kogel, K.H., Oostendorp, M., Staub, T., Ward, E., Kessmann, H., & Ryals, J., 1996. Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates the gene expression. *The Plant Cell*, **8** : 629-43.
- Hammerschmidt, R., Kuc, J. 1982. Lignification is a mechanism for induced resistance in cucumber. *Physiol. Plant Pathol.*, **20** : 61-71.
- Jensen, B.D. Olumide Latunde-Dada, A. Hudson, D. and Lucas, J.A. 1998. Protection of brassica seedlings against downy mildew and damping off by seed treatment with CGA 245704 and activator of systemic acquired resistance. *Pesti. Sci.*, **52** : 63-69.
- Koukal, J. and Conn, E.E. 1961 The metabolism of aromatic compound in higher plants IV purification and properties of Phenylalanine deaminase of *Hordeum vulgare*. *J. Biol. Chem.* **236** : 2692-98.
- Klessig, D.F. and Malamy, J 1994. The salicylic acid signals in plants. *Plant Mol. Biol.*, **26** : 1439-1458.
- Kuc, J. 1982. Induced immunity to plant disease. *Bioscience*, **32** : 854-860.
- Lugtenberg, B.J.J., de Weger LA, Bennet J.W. 1991. Microbial stimulation of plant growth and protection from disease. *Curr. Opinion in Biotech.*, **2** : 457-464.
- Reuveni, R.M. Shimmoni, I.R. Crute 1991. An association between high peroxidase activity in lettuce (*Lactuca sativa*) and field resistance to downy mildew (*Bremia lactuca*). *J. Phytopathol.*, **132** : 312-318.
- Ride, J.P. 1975. Lignification in wounded wheat leaves in response to fungi and its possible role in resistance. *Physiol. Plant Pathol.*, **5** : 124-134.
- Reuveni, R., and M. Perl 1979. Peroxidase isozymes specificity in abscission zone fragments of pepper leaves affected by powdery mildew or stress condition. *Phytopath. Z.*, **96** : 208-214.
- Sharma, Pratibha 2002. Induction of systemic resistance to downy mildew by exogenous application of plant activator. *Annals Plant Prot. Science.*, **10** (1) : 99-103.
- Singh, U.S., Doughty, K.J., Nashaat, N.I., Bennet, R.N., and Kolte, S.J. 1999 Induction of systemic Resistance to *Albugo candida* in *Brassica juncea* by Pre-or Co inoculation with an incompatible isolate. *Plant Pathol.*, **89** : 1226-1232.

DIALLEL ANALYSIS FOR COMPONENTS OF GENETIC VARIATION ON SOME METRIC TRAITS IN BLACK GRAM

SUPRIYO CHAKRABORTY*

*Regional Agricultural Research Station
Assam Agricultural University
Shillongani, Nagaon-782 002, Assam*

ABSTRACT

The estimates of the components of genetic variation from a 6× 6 diallel analysis in blackgram following Hayman's approach revealed that both additive (D) and dominance (H1) gene action, with preponderance of dominance component, were responsible for the expression of eleven metric traits. The estimate of degree of dominance was more than unity for all the traits suggesting the role of over dominance in their inheritance. The distribution of genes with positive and negative effects was a symmetrical in the parents for all the traits except primary branches per plant, clusters per plant and seed yield per plant. Only one gene or gene group controlled the expression of most of the metric traits under study. The heritability in narrow-sense was high (>50%) for harvest index while other traits had low to moderate estimates. To utilize both additive and dominance gene effects simultaneously, biparental mating or reciprocal recurrent selection methodology could be adopted in black gram improvement program. High magnitude of dominance gene effect for all the traits could also be exploited by production of hybrids for commercial planting.

Key words : Hayman's approach, additive, dominance, gene number, blackgram.

Crop yield is influenced by several metric component traits. The study on components of genetic variation is an important tool to determine the genetic constitution of individual metric traits of a plant. These estimates may help in the proper management of genetic availability and in the choice of appropriate and efficient breeding methodology for genetic improvement of crop plants. The present study was, therefore, undertaken to work out the genetic make-up of various metric traits in black gram (*Vigna mungo* L. Hopper).

MATERIALS AND METHODS

Fifteen biparental black gram hybrids (without reciprocal crosses) developed through 6×6 diallel mating design and their six highly adopted black gram parents (T9, PU 19, PDU 10, BL 13, COG 3621 and PDU 87-14) were planted in a randomized block design with three replications at Regional Agricultural Research

Station in Nagaon during kharif 2000. Each genotype was sown in a 2-row plot of 4m length with the spacing of 30 cm × 10 cm. The observations were recorded on 5 randomly selected plants per replication for 11 metric traits namely plant height (cm), primary branches per plant, days to 50% flowering, days to maturity, clusters per plant, pods per cluster, pods per plant, seeds per pod, pod length (cm), harvest index and seed yield per plant (g). The estimates of the components of genetic variation and various ratios were computed as per procedure suggested by Hayman (1954).

RESULTS AND DISCUSSION

Analysis of variance revealed significant genetic variation among the parents and the crosses for most of the traits under study. (Table 1). The parents × crosses interaction was significant for all the traits except plant height and seeds per pod indicating that the performance of the parents varied in different cross combinations.

* Address for correspondence : P.B. No . 35, H.P.O., Nagaon - 782 001, Assam.

Table 1. Estimates of the components of genetic variation for eleven metric traits in blackgram

Component of variation	Plant height	Primary branches per plant	Days to 50% flowering	Days to maturity	Cluster per plant	Pods per cluster	Pods per plant	Seeds per pod	Pod length	Harvest index	Seed yield per plant
D	108.00**	0.19*	5.51*	1.64	31.16*	0.18*	15.61*	0.13*	0.01	0.006*	5.58*
H ₁	273.39**	6.43**	364.27**	243.44**	333.55**	7.46**	1789.84**	5.763**	2.21**	0.083**	44.19**
H ₂	698.94**	5.64**	23.64*	34.02*	319.22**	2.40*	1074.64**	2.24*	0.38*	0.056**	36.02**
F	-392.53**	7.17**	340.42**	206.96**	-72.58*	4.71*	611.08*	-7.84**	-2.61*	0.054**	-2.40**
E	60.63	0.76	0.60	0.53	55.67	0.82	188.26	0.68	0.19	0.002	7.51
h ²	13.25*	4.62*	2.63	46.95**	334.22**	1.55*	963.25**	1.27*	0.42*	0.003*	43.11**

**, * significant at 1% and 5% levels, respectively.

The estimates of the components of genetic variation for eleven metric traits are presented in Table 1. The significant values of additive (D) and dominance (H₁) components for all the traits (except the additive component for days to maturity and pod length) revealed that both additive and dominance gene effects controlled the expression of various traits. The higher estimates of H₁ components over their corresponding D estimates along with more than unity estimates of degree of dominance (Table 2) revealed preponderance of dominance for all the traits under study. The H₂ component was smaller than corresponding H₁ component for all the traits (except plant height) indicating unequal proportion of positive and negative alleles for controlling these traits. The presence of both additive and dominance gene effects for different metric traits in black gram was observed by Dana and Dasgupta (2001); Singh and Singh (1971), Dasgupta and Das (1987), Chakraborty and Borua (1998).

The sum of dominance effects (h²) over the loci was significant for all the traits (except for days to 50% flowering) which revealed that dominance gene effects were more important in comparison to additive gene effects in the expression of the traits. The sign and magnitude of the component F determines the relative frequency of dominant and recessive alleles in the parents. The sign of F was positive for primary branches per plant, days to 50% flowering, days to maturity, pods per cluster, pods per plant and harvest index. This indicated that the dominant alleles were preponderant in the parental population for those traits (Dabholkar, 1992) and irrespective of whether or not the dominant alleles had increasing or decreasing effects (Mather and Jinks, 1971).

The estimate of degree of dominance reveals the type of dominance governing a trait and helps the breeder in choosing a suitable breeding program for genetic improvement. In the present study, the degree of dominance estimate was greater than unity for all the traits indicating over dominance (Table 2). The ratio (H₂/4H₁) was close to 0.25 for primary branches per plant, clusters per plant and seed yield per

Table 2. Estimates of genetic parameters in a 6×6 diallel cross of blackgram following approach

Parameter	Plant height	Primary branches per plant	Days to 50% flowering	Days to maturity	Cluster per plant	Pods per cluster	Pods per plant	Seeds per pod	Pod length	Harvest index	Seed yield per plant
Degree of dominance	1.59	5.81	8.13	12.18	3.27	6.43	7.34	6.65	14.86	3.72	2.81
$H_2/2H_1$	0.64	0.22	0.02	0.03	0.24	0.08	0.15	0.09	0.04	0.17	0.20
KD/KR	0.07	1.89	1.71	1.48	0.47	2.92	3.42	0.64	0.80	* 11.00	1.63
h^2/H_2	0.02	0.82	0.11	1.38	1.05	0.65	0.89	0.57	1.11	0.05	1.19
Heritability in narrow sense (%)	13.74	33.64	30.52	18.48	17.06	5.33	8.83	1.64	3.33	60.01	13.09
Heritability in broad-sense (%)	77.78	56.88	93.59	95.22	65.92	45.33	62.43	44.26	36.67	66.67	60.49

** * significant at 1% and 5% levels, respectively.

plant indicating symmetrical distribution of genes with increasing the decreasing effects in the parents. For the remaining traits, the ratio ($H_2/4H_1$) deviated from 0.25 indicating a symmetrical distribution of genes with increasing the decreasing effects in the parents.

The ratio (KD/KR) measures the proportion of dominant and recessive genes in the parents. The estimate of (KD/KR) deviated from unity for all the traits under study indicating a symmetrical distribution of dominant and recessive genes among the parents.

The ratio (h^2/H_2) measures the number of genes or gene groups which operate the expression of an individual metric trait. In the present study, less than unity magnitude of (h^2/H_2) ratio for most of the traits namely plant height, primary branches per plant, days to 50% flowering, pods per cluster, pods per plant, seeds per pod and harvest index suggested index suggested that only one gene or gene group operated the expression of these metric traits (Kumar and Gupta, 2002). But the estimate of (h^2/H_2) ratio was more than unity for days to maturity, clusters per plant, pod length and seed yield per plant indicating more than one gene or gene group controlling these traits.

The estimate of narrow sense heritability was higher (>50%) for harvest index only and moderate (20-50%) for primary branches per plant and days to 50% flowering. Narrow-sense heritability was low (less than 20%) for plant height, days to maturity, clusters per plant, pods per cluster, pods per plant, seeds per pod, pod length and seed yield per plant. The traits with high heritability could be improved through selection, whereas traits with moderate to low estimates could be improved through hybridization.

To utilize additive (D) and dominance (H) gene effects simultaneously as observed for all the metric traits in the present study, biparental mating or reciprocal recurrent selection in segregating material followed by conventional selection scheme might be adopted in genetic improvement of black gram. High magnitude of

dominance gene effects for all the metric traits could also be exploited by production of hybrids for commercial planting.

ACKNOWLEDGMENT

The author is thankful to the Director of Research (Agri), Assam Agricultural University and the Chief Scientist, RARS, Nagaon for allowing him to undertake the present study.

REFERENCES

- Chakraborty, S. and Borua, P.K. 1998. *Indian J. Genet.*, **58** : 225-227.
- Dabholkar, A.R. 1992. *Element of Biometrical Genetics*, Concept publishing company, New Delhi, 215-325.
- Dana, Indrani and Dasgupta, T. 2001. *Indian J. Genet.*, **61** (2) : 170-17.
- Dasgupta, T. and Das, P.K. 1987. *Indian J. Genet.*, **47** : 265-270.
- Hayman, B.I. 1954. *Genetics.*, **39** : 789-809.
- Kumar, P. and Gupta, S.C. 2002. *Ann. Agric. Res. New Series.*, **23** (1) : 96-100.
- Mather, K. and Jinks, J.L. 1971. *Biometrical Genetics : The study of continuous variation*, Chapman and Hall, London, 2nd Ed.
- Singh, K.B. and Singh, J.K. 1971. *Indian J. Genet.*, **31** : 491-498.

APPROXIMATION OF LEAF AREA BY USING LEAF DIMENSIONS IN MANGO (*MANGIFERA INDICA* L.)

ACHAL SINGH

Central Institute for Subtropical Horticulture
Rehmankhura, P.O. Kakori, Lucknow-227107

ABSTRACT

Different curve models were fitted for the estimation of leaf area in mango using leaf length (L) and breadth (B) as independent factors. four regression equation were fitted to find out the best mode for leaf area (LA) estimation in each cultivar. Among the various functions, leaf length (L), breadth (B), fresh weight (FW), dry weight (DW), L and B were found most suitable for determining the leaf area.

Key words : Mango cultivars, leaf area, multiple linear regression.

Mango (*Mangifera indica* L.) is the most important fruit crop in tropical and subtropical regions of India. Leaves are important for photosynthesis, respiration, evaporation and biochemical reactions of the plant. The shape and size of leaf plays important role in the growth of plants. Although, the rate of expansion of the leaves of mango is often very rapid. Leaves having less width and more length are important features to control the process of evaporation in case of field having water in scarcity. It has been observed that the leaf area depends on a number of characters, like leaf length, leaf width, fresh weight and dry weight. It was accepted that the leaf area is a linear function of leaf characters. The leaves are ovate-lanceolate with a small drip tip and the different maturity stages of leaves may cause changes in the length and width. Therefore, if one has representative sample reflecting the scenario of leaf distribution on the tree and recommending a formula involving linear relationship, may be useful for predicting LA. Therefore, an attempt was made to estimate the leaf area by using different leaf characters of commercial mango cultivars.

MATERIALS AND METHODS

Thirty leaves of full grown (20 years old) trees of mango cultivars Dashehari, Langra and Bombay Green have been randomly collected. Leaf area was measured with a portable leaf area

meter (LI-3000). These characters were used to calculate the leaf area for the particular cultivar by applying multiple linear regression and these characters were fitted into the regression equation. The multiple linear regression were calculated using MSTATC.

RESULTS AND DISCUSSION

Various models for predicting the leaf area of mango using different leaf characters such as leaf length (L), breadth (B), fresh weight (FW) and dry weight (DW) were analysed by applying the inclusion method. It is well established fact that for a rectangular entity area is a product of length and breadth. It is clear from Table 1 that coefficient of determination varied significantly (84.6 – 96.7%) with respect to different variables in different cultivars. Variation in coefficient of determination (R^2) was maximum (84.6 – 96.6%) in case of Langra, however, Dashehari showed comparatively less variation in R^2 , (87.7, 89.3 and 84.6 per cent was in cvs Dashehari, Bombay green and Langra, respectively when leaf length and leaf fresh weight were used in the regression equation except cv, Langra, for which breadth and fresh weight accounted for minimum coefficient of determination (R^2). On the other hand the high coefficient of determination (R^2) i.e., 92.7, 96.6, 96.7% in cvs, Dashehari, Langra, Bombay Green was recorded when leaf length, leaf breadth and leaf fresh weight were used in

Table 1. Estimation of leaf area (LA) of mango with different leaf dimensions

Sl.No.	Characters for regression equation	Cultivars	Equation	Coefficient of determination R^2 (%)
1.	L, B	Dashehari	$-50.50 + 3.21 L + 12.05 B$	92.6
		Langra	$-69.09 + 4.44 L + 11.15 B$	96.20
		Bombay Green	$-48.15 + 3.78 L + 9.23 B$	96.6
2.	L, FW	Dashehari	$-15.04 + 2.23 L + 21.02 FW$	87.7
		Langra	$-43.59 + 5.25 L + 10.65 FW$	89.0
		Bombay Green	$-23.17 + 3.67 L + 12.30 FW$	90.2
3.	B, FW	Dashehari	$18.99 + 10.35 B + 17.16 FW$	90.8
		Langra	$-40.29 + 15.37 B + 14.31 FW$	84.6
		Bombay Green	$-19.43 + 9.19 B + 16.20 FW$	89.30
4.	L,B,FW	Dashehari	$-44.34 + 2.71 L + 11.08 B + 3.89 FW$	92.7
		Langra	$-65.90 + 4.08 L + 10.56 B + 3.82 FW$	96.6
		Bombay Green	$-45.12 + 3.49 L + 8.70 B + 2.17 FW$	96.7

L = Leaf length, B = leaf breadth, FW = leaf fresh weight.

the regression equation.

It is interesting to note that coefficient of determination (R^2) is satisfactory in the test cultivars (92.2% in Dashehari, 96.2% in Langra and 96.6% in Bombay green) even after excluding the leaf fresh weight from the regression equation. Thus it is clear from the results that the inclusion of leaf fresh weight in regression equation has no significant impact on increasing coefficient of determination. On the basis of this finding the inclusion of leaf dry weight in the regression equation was not tried for estimating

the leaf area. Similarly, Mohan Kumaran *et al.* (1964) also reported that a model which gave a higher coefficient of determination (R^2) value in one case did not necessarily give the higher coefficient of determination (R^2) value in other cases.

On the basis of the best model obtained in present study, the values of the leaf area predicted by using L and B clearly showed the suitability of model under which the observed and predicted values seems to be very close (Table 2).

Table 2. The predicted values of the leaf area of different mango cultivars by using the best models of respective cultivars

Leaf no.	Leaf Area					
	Dashehari		Bombay green		Langra	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
1	85.89	62.27	41.40	43.97	75.91	77.68
2	46.90	53.75	77.80	66.98	112.47	110.31
3	32.92	37.12	42.68	45.32	95.75	101.54
4	86.59	89.77	59.60	59.47	89.72	94.18
5	66.20	59.22	37.59	35.91	87.83	80.70
6	102.70	100.62	54.80	56.57	105.58	111.04
7	47.26	49.17	32.80	30.37	129.12	122.47
8	67.78	69.43	45.23	46.41	86.75	83.90

contd...

Table 2 contd...

9	41.21	45.15	62.13	58.59	103.14	105.80
10	26.95	24.25	44.36	46.58	88.67	90.54
11	55.16	63.24	74.67	78.19	84.72	88.94
12	81.63	73.69	40.55	41.66	52.80	49.95
13	78.25	83.33	52.12	52.96	94.22	82.84
14	57.53	55.11	58.32	57.49	74.86	70.78
15	48.84	56.40	52.64	53.93	125.88	125.73
16	40.56	45.55	59.45	62.06	136.67	732.74
17	61.62	64.85	42.68	44.35	91.34	95.60
18	67.72	66.05	73.33	73.61	70.04	73.35
19	28.15	27.87	69.82	70.09	85.62	88.70
20	34.60	36.15	54.82	55.65	91.40	95.88
21	32.73	33.50	44.54	44.60	45.34	46.94
22	94.49	92.58	82.91	79.71	42.80	41.71
23	50.76	56.81	36.26	37.76	102.69	92.14
24	49.86	47.96	34.35	29.44	59.76	52.79
25	55.52	56.01	24.54	27.09	57.07	59.79
26	75.40	72.48	33.15	34.95	51.08	55.90
27	51.17	52.47	30.90	31.16	65.44	68.38
28	23.32	19.83	31.84	31.29	77.67	81.40
29	30.33	33.02	33.40	35.74	98.28	98.46
30	17.30	11.55	20.16	15.51	51.58	52.88

REFERENCE

Mohan Kumaran, Krishnamurthy, N.S.; Rao, V.N.M.
and Seshu, K.A. 1964. Estimation of leaf area in

some varieties of grapes. *Sout Indian Hort.*, 11 : 50-61.

STABILITY STUDIES OF INBRED AND THEIR SINGLE CROSSES IN MAIZE (ZEA MAYS L.)

ARUN KUMAR* AND N.N. SINGH

Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Maize is an open pollinated crop where heterosis has been exploited extensively world over. Therefore, the adaptability of the genotypes of their stability over a wide array of environments is all the more important. To release variety/hybrid with an above average performance across the environments is one of the prime interests of the breeders. In the present study, 7 parents and their 21 single crosses and 2 standard checks were used for estimating the stability parameters based on Eberhart and Russels' model by raising the crop at 4 diverse locations viz., Ajitmal (UP), Delhi, Banswara (Rajasthan) and Uchani (Haryana) during kharif 1998. The stability analysis exhibited highly significant variation for genotypes, environment, $G \times E$ environment (linear), $G \times E$ (liner) and pooled deviation for most of the characters. Among the parents no specific trend of consistency in the stability could be observed. On the other hand, a large number of crosses have been found stable.

Key words : Maize, *Zea mays* L., stability.

Maize is an important allogamous cereal. It is the only food grain crop where heterosis has been extensively exploited world over. However, most of the countries could utilize this phenomenon through double cross hybrids, mainly on account of easiness and cheapness of seed production. Recently, some of the countries like USA and China have embarked upon the commercial exploitation of this phenomenon in maize by raising the single cross hybrids and thus could replace the conventional double cross hybrids on account of profitability and economic viability.

It is established fact that apart from genetically diverse, heterotic and better combining inbreds, stability of their hybrids over a wide array of environments is equally important. However, selection for stability parameters is not possible until a model with suitable parameters is applied to provide the criteria necessary to rank the varieties for stability. Most of the breeders are interested in the release of the hybrid/variety with an above average performance across the environments. Hence, the hybrid/variety with high mean ($\bar{x}$), unit regression coefficient (b_i) and smallest

deviation from the regression (S^2_d), would be the automatic choice for the selection. According to Langer et al. (1979), the regression coefficient is a measure of response to varying environments. The mean square deviation from linear regression is a true measure of production stability. Therefore, keeping in view the importance of this parameter, the present study was undertaken in maize.

MATERIALS AND METHODS

The test materials of maize, as illustrated in Table 1, comprised of 7 inbred parents, 21 F_1 crosses which were developed through diallel crossing excluding reciprocals and two released hybrids as checks. The experiments on these 30 genotypes were laid out during kharif season of 1998 in randomized block design with three replication at four diverse locations viz., Ajitmal (UP), Banswara (Rajasthan), Uchani (Haryana) and Delhi. The observations were recorded on ten randomly selected plants in each genotype on 11 traits viz., days to 50% tasseling, silking and maturity; plant and cob height; cob length and girth; number of kernels rows per cob; number of kernels per row; 100-kernel weight and grain yield per plant.

*National Phytotron Facility.

Table 1. Details of the inbreds and checks of maize used in the study

S.No.	Original Code	Constitution	Code used in the study
1.	4084	CMIP MNTV 2-3-5-7-x-#-1	1
2	4086	CMIP MNTV 7-#-x-6-5-4-3-x-1-#	2
3	4088	CMIP MNTV 2-x-21-1-1-2-x-1-#	3
4	4089	CMIP MNTV 2-x-21-3-2-1-1-x-1-#	4
5	4090	CMIP MNTV 2-x-32-4-1-2-x-1-#	5
6	4091	CMIP MNTV 7-x-12-1-1-1-x-1-#	6
7	4093	CMIP MNTV 7-x-12-1-1-1-x-1-#	7
8	Ganga Safed 2	(CM 400 × CM 300) × CM 600	Check 1
9	DHM 103	(CM 120 × CM 118) × (CM 119 × CM 208)	Check 2

The phenotypic stability analysis of crosses/ varieties grown under different environments was carried out following Eberhart and Russell (1966), which is based on the following model that enables partitioning the genotype × environment interactions of each variety into two parts (i) the deviation due to the response of variety - environmental indices (sum of squares due to regression) and (ii) the unexplainable deviations from the regression of the environmental index.

RESULTS AND DISCUSSION

Analysis of variance for stability for parents and F_1 s for 11 characters was carried out segregating total variation due to genotypes (G), environments (E), $G \times E$, $E + (G \times E)$, environment (linear), $G \times E$ (linear) and pooled deviation. Results elaborated in Table 2 indicated highly significant differences among the genotypes in respect of all the characters. Similarly, the four experimental sites chosen for experimentation were so diverse that mean sums of squares for environments were highly significant for all the characters, suggesting that rigorous screening of the genotypes for stability should be done. Excepting for days to 50% maturity, for all the characters, the mean sums of squares due to $(G \times E)$ linear component were found highly significant. It indicated that the average performance of the genotypes for these traits

varied significantly. Debnath and Azad (1992) also observed $G \times E$ interactions for grain yield, ear length and ear diameter and 100-grain weight. The non-linear component (pooled deviation) was also found highly significant for all the characters, indicating considerable genetic diversity in the test material, the highest being for plant height, followed by grain yield and cob height. Such non-linear deviations might be of practical value of conduct the test for assessing the utility of multiple regression models to know more critical about the complex mechanisms of adaptation.

The characters having more loci should have considerable interaction and no stability. Days to 50% silking and tasseling and grain yield with large number of major gene groups are considered for low stability. On the other hand, rest of the characters are supposed to be moderately to highly stable with low environmental interactions.

The significant $G \times E$ (linear) component emphasized that unit slope could be identified. Accordingly, 3 kinds of linear responses, namely $b = 1$, $b > 1$ and $b < 1$ have been generally observed in the present study. Sporadic negative values of b_i were observed for days to maturity, cob length, cob girth, number of kernel rows, number of kernels/row and grain yield (Table 3). Such type of linear response could be

Table 2. Pooled ANOVA for stability for 11 characters in maize grown at four locations during 1998

Source of variation	d.f.	m.s.s.										
		1	2	3	4	5	6	7	8	9	10	11
Genotype (G)	29	6.79**	1.74**	3.12*	515.00**	140.34**	2.59**	0.13**	1.53*	22.03**	7.72	475.30**
Environment (E)	3	244.15**	169.76**	516.2**3	15846.77**	7178.97**	90.51**	0.39**	8.98**	253.80**	163.86**	256.31**
Geno. $\times$ Env. (G $\times$ E)	87	3.96**	1.82**	2.35**	152.61**	48.97**	1.83**	0.05**	1.15**	8.64**	4.86**	99.16**
E + (G $\times$ E)	90	11.97	9.35	19.47	676.34	286.641	4.79	0.06	1.41	16.81	10.16	104.40
Environment (linear)	1	732.46**	509.27**	1548.53**	47595.44**	21537.00**	271.53**	1.18**	26.93**	761.42**	491.55**	768.94**
G $\times$ E (linear)	29	3.11	4.25**	4.37**	129.47	51.03**	3.00**	0.07**	1.78**	11.05**	6.71**	155.95**
Pooled deviation	60	4.24**	3.48**	1.29**	158.68**	46.34**	1.21**	0.03**	0.81**	7.19**	3.80**	68.41**
Pooled Error	232	1.46	1.68	1.54	45.77	13.12	0.35	0.03	0.58	2.93	1.83	21.94

* and ** denote significance at 5% and 1% levels, respectively

L1 = Ajitmal, L2 = Banswara, L3 = Delhi, L4 = Uchani

1 = Days to 50% tasseling

2 = Days to 50% silking

3 = Days to 50% maturity

4 = Plant height

5 = Cob height

6 = Cob length

7 = Cob girth

8 = No. of kernel rows/cob

9 = No. of kernels/row

10 = 100-kernel weight

11 = Grain yield/plant

Table 3. Stability parameters for different characters 7 parents and their 21 crosses and 2 checks of maize grown during 1998 at four locations

Parents/ hybrids/ checks	Days to 50% tasseling			Days to 50% silking			Days to 50% maturity			Plant height		
	X	b_i	S^2_m	X	b_i	S^2_m	X	b_i	S^2_m	X	b_i	S^2_m
1	53.08	0.33	3.33	54.50	0.34	0.39	85.75	1.25**	0.78	139.46	0.46	590.35
2	52.75	1.22**	3.70	55.67	0.86	0.63	85.92	1.28**	0.47	153.25	0.71*	401.09
3	52.00	1.23**	7.17	55.00	0.80	4.95	86.33	0.82**	2.45	149.49	0.49	98.09
4	54.08	0.44	2.20	54.50	1.26	-0.53	86.00	1.31**	-0.39	152.44	1.28	82.17
5	52.08	0.96*	2.20	54.50	1.94**	-0.53	86.00	1.31**	-0.39	152.44	1.28**	82.17
6	53.75	1.04**	19.26	57.08	0.60	11.88	85.50	1.09**	3.10	146.89	0.87**	210.05
7	52.08	1.48**	11.25	54.92	1.05*	23.57	84.75	0.83**	0.34	141.28	0.67*	65.10
1×2	50.25	0.61	5.93	52.75	0.52	3.48	8.00	-0.03**	0.03	144.67	0.79*	100.07
1×3	49.33	1.07**	2.53	51.50	1.17*	0.08	84.00	0.76**	1.10	166.17	1.00**	113.37
1×4	51.08	1.31**	3.47	53.17	1.37*	1.96	85.00	1.17**	-0.08	173.09	1.15**	221.80
1×5	50.67	0.82	12.95	53.83	1.41*	13.62	84.58	1.12**	1.44	170.73	1.01**	97.55
1×6	49.42	1.07**	3.59	51.83	1.04*	0.73	84.67	1.22**	0.87	15.78	1.52**	-9.64
1×7	50.33	0.91*	1.16	53.08	0.92*	1.61	84.42	0.86**	-0.38	160.87	0.65*	165.05
2×3	50.25	1.37**	0.25	52.75	1.28*	0.87	84.17	0.73**	1.42	165.02	1.10**	2.92
2×4	51.67	0.57	0.28	53.83	0.34	0.94	84.17	1.17**	0.12	154.21	0.63*	142.12
2×5	50.08	1.39**	0.31	53.17	1.28*	0.87	84.00	0.75**	1.53	159.03	1.42**	301.06
2×6	51.33	0.75	0.27	54.25	0.19	-0.06	85.17	1.10**	0.87	167.32	0.92**	138.11
3×7	51.00	1.24**	3.67	53.33	1.23*	2.09	85.33	1.31**	0.73	160.58	1.16**	48.91
3×5	50.17	1.25**	0.06	53.58	0.64	-0.48	85.67	1.10**	-0.02	162.47	1.19**	38.60
3×6	49.75	1.35**	2.93	52.75	1.61*	1.86	84.25	0.92**	-0.33	164.93	1.04**	94.19
3×7	50.08	1.52**	0.38	54.25	1.88**	1.82	84.92	1.14**	0.88	173.70	1.36**	182.96
4×5	52.17	0.20	0.56	53.08	1.03	0.18	84.92	0.99**	0.16	169.72	1.24**	5.27
4×6	51.17	0.85*	0.56	53.08	1.03*	0.18	84.92	0.99**	0.16	169.72	1.27**	5.27
4×7	51.83	0.70	0.65	54.75	0.61	1.66	85.00	0.65**	1.37	157.25	0.86**	5.43
5×6	48.67	1.51**	3.04	51.25	1.67*	2.55	84.25	0.46**	1.28	166.70	1.31**	403.45
5×7	50.50	1.06*	9.21	54.35	1.67*	5.01	86.08	1.19**	1.05	166.98	1.24**	27.97
6×7	51.33	0.56	0.34	53.58	0.38	0.13	85.50	1.27**	-0.46	171.65	1.21**	100.03
Check 1	50.83	1.08**	0.50	53.83	0.71	3.22	84.15	1.15**	0.21	182.37	1.22**	148.45
Check 2	52.08	0.92*	0.33	54.04	1.00	0.73	87.00	0.96**	3.19	189.43	1.13**	95.10
Mean	51.12	1.00	-	53.84	1.00	-	85.05	1.00**	-	162.28	1.00	-
S.E. (±)	1.19	0.42	-	1.08	0.45	-	0.65	0.16**	-	7.27	0.31	-

* and ** denote significance at 5% levels, respectively.

contd...

Table 3 contd...

Parents/ hybrids/ checks	Cob height (cm)			Cob length (cm)			Cob girth (cm)			No. of kernel rows/cob		
	X	b _i	S ² m	X	b _i	S ² m	X	b _i	S ² m	X	b _i	S ² m
1	52.51	0.36	162.13	12.28	-0.19	6.01	3.88	0.42	0.08	14.10	2.55**	-0.15
2	57.95	0.79**	127.13	14.23	0.56	1.79	3.58	-0.66	0.00	13.88	0.16	1.74
3	55.32	0.64	94.22	13.47	1.32**	-0.05	3.65	-0.86	0.00	13.23	-0.22	0.18
4	60.97	1.08**	42.13	13.02	0.26	0.17	3.78	-1.02	0.00	13.10	-0.55	1.77
5	59.56	0.81**	10.70	14.32	0.25	0.69	3.79	-0.40	0.00	13.03	-0.30	-0.09
6	51.61	0.70**	-2.03	13.42	0.33	-0.04	3.65	-0.23	0.07	13.97	1.76	-0.07
7	57.68	0.79**	5.40	13.80	-0.04	0.05	3.79	0.64	0.03	14.22	-2.16*	2.10
1×2	52.77	0.79**	17.53	13.22	1.37**	2.19	3.98	1.17	0.02	14.22	-0.65	0.80
1×3	64.22	1.44**	73.78	14.02	1.26**	0.71	3.91	0.58	0.00	13.65	-0.96	0.26
1×4	66.71	1.43**	124.03	14.82	1.34**	3.61	3.95	1.97*	0.03	14.43	-0.77	1.77
1×5	66.44	0.91**	53.77	14.53	1.40**	0.02	3.88	0.80	0.02	13.73	1.03	0.05
1×6	69.45	0.94**	-4.32	14.98	1.17**	0.52	4.03	0.77	-0.03	14.32	2.23*	0.09
1×7	67.53	0.78**	32.99	14.03	1.25**	1.10	3.97	-0.03	0.00	13.58	1.81	0.89
2×3	63.60	.00**	4.84	14.73	1.54**	1.10	4.29	1.07	-0.01	14.97	2.78**	1.03
2×4	62.98	1.75**	4.83	14.97	1.02**	0.21	4.18	1.00	0.05	14.22	0.02	0.44
2×5	63.63	1.17**	30.21	14.13	0.35*	0.89	4.08	3.90**	0.04	14.23	1.70	0.26
2×6	65.18	0.79**	-4.17	14.47	1.76**	0.22	4.17	1.46	0.11	14.82	1.92*	0.74
2×7	63.49	1.01**	44.70	14.07	0.70	0.00	4.29	2.97**	0.01	15.50	2.53**	0.08
3×4	66.01	0.79**	3.5	15.33	1.24**	0.20	4.02	0.84	0.01	13.73	3.10**	0.13
3×5	65.45	0.97**	11.16	14.47	0.14*	-0.02	3.93	0.22	0.05	14.35	0.56	0.27
3×6	63.97	1.35**	27.37	14.99	0.92*	0.28	4.12	0.41	-0.01	14.50	0.12	0.14
3×7	75.03	1.21**	17.58	15.18	0.81*	2.34	3.94	1.77	0.00	13.13	2.47**	1.88
4×5	64.473	1.05**	46.42	14.09	1.29**	2.37	4.12	1.80	0.04	13.65	1.35	0.06
4×6	65.71	0.96**	27.92	15.93	1.99**	0.58	4.10	0.29	0.03	12.98	1.90*	1.10
4×7	62.95	1.31**	1.65	15.20	1.70**	1.48	1.22	2.04*	0.00	14.17	1.90*	-0.05
5×6	69.60	1.28**	119.27	14.82	0.65	0.91	4.02	0.77	0.03	14.22	0.46	2.62
5×7	69.61	1.36**	11.99	14.38	1.18**	4.24	1.15	0.64	0.05	13.73	2.29*	-0.18
6×7	70.05	0.98**	61.12	14.83	1.741**	0.74	4.16	0.19	0.05	13.77	2.34*	0.59
Check 1	70.18	1.31**	48.10	15.48	1.22**	0.32	3.92	0.11	0.04	13.52	-0.39	0.24
Check 2	73.87	1.25**	7.67	15.33	1.47**	0.12	4.01	0.02	0.00	12.82	0.01	0.05
Mean	63.95	1.00	-	14.42	1.00	-	3.98	1.00	-	13.93	1.00	-
S.E. (±)	3.93	0.25	-	0.63	0.36	-	0.10	0.093	-	0.51	0.95	-

* and ** denote significance at 5% levels, respectively.

contd...

Table 3 contd...

Parents/ hybrids/ checks	No. of kernels per row			100-kernel weight (g)			Grain yield per plant (g)		
	X	b_i	S^2_m	X	b_i	S^2_m	X	b_i	S^2_m
1	18.61	1.08*	18.90	17.05	1.95**	4.30	44.63	2.91	205.66
2	23.58	1.11*	1.75	17.48	1.80**	4.06	49.23	0.49	20.04
3	22.62	1.88**	17.01	16.04	1.45**	5.30	63.07	0.52	111.84
4	22.58	0.74	0.48	16.86	1.06*	9.08	57.47	-2.9	44.49
5	23.00	0.36	0.31	18.38	1.52**	2.95	59.85	-1.94	1.20
6	21.88	0.44	-0.31	16.22	1.57**	0.25	55.51	-1.52	79.93
7	21.91	-0.50	-00.30	16.89	1.58**	-0.24	50.28	1.86	40.28
1×2	24.95	0.86	8.87	18.43	0.94*	11.04	76.52	-0.70	44.48
1×3	25.82	1.31*	2.19	18.00	1.70**	5.49	72.27	-1.10	0.00
1×4	26.75	2.01**	3.93	19.31	0.41	8.72	79.05	-0.89	92.06
1×5	24.37	0.69	0.34	16.89	1.02*	0.15	62.61	0.30	0.44
1×6	29.33	0.66	0.49	18.33	0.73	0.15	72.43	0.39	18.80
1×7	27.58	0.68	-0.18	18.08	1.09*	6.75	58.70	5.29**	96.08
2×3	25.96	1.20*	1.52	18.21	1.64**	1.69	68.04	2.89	5.21
2×4	26.66	-0.39	-0.05	18.31	1.44**	4.19	86.85	-0.56	50.68
2×5	27.39	0.25	0.34	17.86	0.45	2.04	75.98	-0.48	227.46
2×6	24.75	1.04*	17.26	18.82	0.33	-0.34	76.68	3.82*	58.38
2×7	24.86	0.50	1.04	18.80	0.04	3.24	75.65	-2.07	121.08
3×4	25.20	1.52*	10.14	18.84	0.81	8.00	64.32	2.91	39.72
3×5	25.75	0.79	1.89	17.33	0.82	-0.35	66.02	-2.87	5.98
3×6	25.79	1.27*	5.48	18.07	0.79	4.74	74.54	-0.27	69.88
3×7	28.49	0.99	12.61	17.08	0.46	2.31	78.25	0.18	30.95
4×5	23.10	0.98	14.34	19.34	0.68	2.65	62.10	5.83**	39.03
4×6	25.39	2.11**	2.76	19.74	0.89	0.61	85.92	0.30	53.79
4×7	26.51	0.57	21.20	16.87	0.57	3.49	72.10	4.96**	-3.58
5×6	26.68	1.02	6.86	17.02	1.51**	0.19	74.87	-0.23	130.51
5×7	25.58	0.28	12.80	17.92	0.49	-0.42	56.49	4.43**	55.77
6×7	27.47	1.52*	3.00	18.48	-0.35	-0.49	77.22	3.77	70.39
Check 1	27.33	2.44**	22.64	17.14	1.03*	5.54	74.32	1.08	58.31
Check 2	27.98	1.59*	-0.63	19.27	-0.40	0.61	80.85	3.42	63.92
Mean	25.29	1.00	-	17.90	1.00	-	68.39	1.00	-
S.E. (±)	1.54	0.53	-	1.12	0.48	-	4.77	1.63	-

* and ** denote significance at 5% levels, respectively.

attributed to inadequacy of scale used for the analysis and for the inherent behavior of the genotypes (Knight, 1970). The large variation in the regression coefficients indicated that the parents and their progenies had their different environmental responses. The parent 4 for five characters, 5 and 6 for two characters each and 1, 2 and 7 for one character each showed stable

performance. Among the F_1 s, 1×3 , 1×5 , 1×6 and 1×7 for two characters : 2×3 , 2×6 , 3×6 , 4×5 and 4×6 for three characters; 2×4 for one character showed stable performance. The two checks showed stability in performance for a large number of characters. The above hybrids could be utilized as released cultivars.

REFERENCES

- Debnath, S.C. and Azad, M.A.K. 1992. The impact of genotype - environment interaction on the determination of the components of variation and other genetic parameters in maize. *Acta Agronomica Hungaria*, 41 : 215-255.
- Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.*, 6: 36-40.
- Knight, R.C. 1970. The measurement of interpretation of genotype $\times$ environment interactions. *Euphytica*, 19 : 225-235.
- Langer, S., Frey, K. and Bailey, T. 1979. Association among production response and stability indices in oat varieties. *Euphytica*, 28 : 17-24.

CHARACTER ASSOCIATION AND PATH ANALYSIS OF MORPHOLOGICAL ATTRIBUTES IN GREEN GRAM (*VIGNA RADIATA* (L.) WILCZEK)

G. SREEDEVI AND M. REDDY SEKHAR

Department of Genetics & Plant Breeding
S.V. Agricultural College, Tirupati-517 502, Andhra Pradesh

Character association reveals the type, nature and magnitude of correlation between yield components with yield and among themselves. A knowledge of inter-relationships among yield components is essential when selection for improvement is to be effective in segregating generations. Path analysis identifies the yield components which directly and indirectly influence the yield. In the present study, 21 F_4 progenies were grown in a randomized block design with three replications at S.V. Agricultural College Farm, Tirupati during Rabi 1998. Each entry was sown in 2 rows of 3 m length with a spacing 30×15 cm. Observations were recorded on randomly selected five competitive plants in each progeny in each replication for all the morphological attributes except days to 50% flowering and days to maturity which were recorded on per plot basis. Correlation and path coefficients were computed following standard statistical procedures (Johnson *et al.* 1995; Dewey and Lu, 1959).

The genotypic correlation coefficients were higher than phenotypic correlation coefficients indicating the environmental influence on expression of characters (Table 1). The characters pods per plant, seeds per pod and clusters per plant displayed positive significant association with grain yield. Significant and positive inter-se correlations were also recorded among these characters which indicated that grain yield per plant was a totality of these characters. Simultaneous selection of these characters must be adopted to achieve substantial improvement in yield. These results are in agreement with those obtained by Misra and Sahu (1985) for pods per plant, Veerabadhiran and Jehangir (1995) for seeds per pod and Pundir *et al.* (1992) for clusters per plant. Days to 50 per cent flowering expressed

strong positive association with day to maturity. Similarly, clusters per plant displayed strong positive association with pods per plant and pods per plant with seeds per pod. These results were in consonance with the findings of Borah and Hazarika (1995).

Grain yield is a product of interaction of component traits, which are either positively or negatively correlated with each other. Better understanding of direct and indirect influences of various characters on grain yield would, however, emerge from the path analysis which showed that pods per plant and seeds per pod contributed very high positive direct effects on yield (Table 2). These characters also displayed significant positive association with yield. Similar results were reported by Misra and Sahu (1985), Singh *et al.* (1995), Sarma and Talukdar (1996) and Natarajan *et al.* (1998) in greengram. On contrary, Pods per cluster, pod length, clusters per plant and 100-seed weight recorded negative direct effects but showed positive correlation with grain yield per plant via indirect effects via pods per plant followed by seeds per pod. However, 100-seed weight exerted negative indirect effects via pods per plant and days to 50 per cent flowering resulting in negative association with yield.

Critical analysis of path coefficients indicated that selection for pods per plant, seeds per pod and clusters per plant are more important and promising traits contributing for seed yield. Further, indirect effects of most of the characters via pods per plant and seeds per pod were high and positive, hence, these characters may be useful as selection criteria to isolate superior lines for high grain yield in greengram.

Table 1. Phenotypic (r_p) and genotypic (r_g) correlation co-efficients among morphological attributes in $21F_4$ progenies of greengram

Character	Days to maturity	Plant height	Clusters per plant	Pods per plant	Pods per cluster	Pod length	Seeds per pod	100 Seed weight	Grain yield per plant
Days to 50% flowering	(r_p) 0.6236**	0.1502	0.0774	-0.0393	0.0562	-0.1291	-0.0087	-0.1133	0.0624
	(r_g) 0.8261	0.1275	0.4120	0.1339	0.1329	0.0359	0.1082	-0.8523	0.0654
Days to Maturity	(r_p) 0.3772	0.3772	-0.0363	0.0550	0.2381	-0.0617	0.0011	-0.2053	0.0749
	(r_g) 0.5259	0.5259	-0.0191	0.1159	0.4149	-0.2495	-0.0295	-0.6311	0.0447
Plant height	(r_p) 0.1208		0.1208	0.2833	0.1490	0.0146	0.0429	-0.4381*	0.2294
	(r_g) 0.1927		0.1927	0.3160	0.0783	0.6920	0.3295	-0.6427	0.3896
Clusters per plant	(r_p) 0.6808**			0.6808**	-0.0872	0.1647	0.2153	-0.1322	0.5120*
	(r_g) 0.6496			0.6496	0.4402	-0.7144	0.8775	0.1012	0.8556
Pods per plant	(r_p) 0.4280				0.4280	0.3014	0.5452*	-0.1098	0.6805**
	(r_g) 0.6975				0.6975	0.4887	1.0086	0.1340	1.1093
Pods per cluster	(r_p) -0.1002					-0.1002	0.2748	-0.0933	0.1209
	(r_g) 0.8698					0.8698	0.2218	-0.3955	0.4402
Pod length	(r_p) 0.1603						0.1603	0.0213	0.1245
	(r_g) 0.8458						0.8458	-0.3571	1.0662
Seed per pod	(r_p) 0.0637							0.0637	0.5779**
	(r_g) -0.0916							-0.0916	1.0178
100-Seed weight	(r_p) -0.0793								-0.0793
	(r_g) 0.0378								0.0378

*Significant at P = 0.05 ** Significant at P = 0.01.

Table 2. Phenotypic (p) and genotypic (g) path co-efficients among grain yield per plant and 9 morphological attributes in greengram

Character	Days to 50% flowering	Days to maturity	Plant height	Clusters per plant	Pods per plant	Pods per cluster	Pod length	Seeds per pod	100 Seed weight	Grain yield per plant
Days to 50% flowering	(p) 0.0514	0.0306	0.0049	-0.0040	-0.0280	-0.0175	0.0198	0.0027	0.0026	0.0624
	(g) -0.5776	0.2023	-0.0338	-0.1270	0.0669	0.0018	-0.0097	0.1214	0.4211	0.0654
Days to Maturity	(p) 0.0321	0.0490	0.0122	0.0019	0.0393	-0.0741	0.0095	0.0003	0.0048	0.0749
	(g) -0.4772	0.2449	-0.1396	0.0059	0.0579	0.0058	0.0673	-0.0331	0.3128	0.0447
Plant height	(p) 0.0077	0.0185	0.0323	-0.0063	0.2024	-0.0464	-0.0022	0.0132	0.0102	0.2294
	(g) -0.0736	0.1288	-0.2654	-0.0594	0.10579	0.0011	-0.1867	0.3695	0.3175	0.3896
Clusters per plant	(p) 0.0040	-0.0018	0.0039	-0.0521	0.4863	0.0272	-0.0253	0.0666	0.0031	0.5120*
	(g) -0.2380	-0.0047	-0.0511	-0.3083	0.3246	0.0061	0.1928	0.9841	-0.0500	0.8556
Pods per plant	(p) -0.0020	0.0027	0.0092	-0.0355	0.7144	-0.1333	-0.0462	0.1687	0.0025	0.6805**
	(g) -0.0774	0.0284	-0.0839	-0.2003	0.4997	0.0097	-0.1319	1.1311	-0.0662	1.1093
Pods per cluster	(p) 0.0029	0.0117	0.0048	0.0045	0.3058	-0.3114	0.0154	0.0850	0.0022	0.1209
	(g) -0.0767	0.1016	0.0208	-0.1357	0.3485	0.0139	-0.2347	0.2488	0.1954	0.4402
Pod length	(p) -0.0066	-0.0030	0.0005	-0.0084	0.2153	0.0312	-0.1534	0.0496	-0.0005	0.1245
	(g) -0.0208	-0.0611	-0.1836	0.2203	0.2442	0.0121	-0.2699	0.9486	0.1764	1.0662
Seed per pod	(p) 0.0004	0.0001	0.0014	-0.0112	0.3895	-0.0856	-0.0246	0.3095	-0.0015	0.5779**
	(g) -0.0625	-0.0072	-0.0874	-0.2705	0.5040	0.0031	-0.2283	1.1215	0.0453	1.0178
100-Seed weight	(p) -0.0058	-0.0101	-0.0142	0.0069	-0.0784	0.0290	-0.0033	0.0197	-0.0232	-0.0793
	(g) 0.4923	-0.1550	0.1705	-0.0312	0.0670	-0.0055	0.0964	-0.1027	-0.4940	0.0378

*Significant at P = 0.05** Significant at P = 0.01

REFERENCES

- Borah, H.K. and Hazarika, M.H. 1995. Genetic variability and character association in some exotic collections of greengram. *Madras Agric. J.*, **82** (4) : 268-271.
- Dewey, D.R. and Lu, K.H. 1959. Correlation and path coefficient analysis in components of crested wheat grass seed production. *Agronomy J.*, **51** : 515-518.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Genotypic and phenotypic correlations in Soybean and their implications in selection. *Agronomy J.*, **47** : 477-483.
- Misra, R.C. and Sahu, B.C. 1985. Genetic parameters, correlation and path coefficient analysis in greengram (*Vigna radiata* (L.) wilczek). *The Andhra Agric. J.*, **32** : 87-91.
- Natarajan, C., Thiyagarajan, K. and Rathnaswamy, R. 1988. Association and genetic diversity studies in greengram (*Vigna radiata* (L.) Wilczek). *Madras Agric. J.*, **75** : 238-245.
- Pundir, S.R., Gupta, K.R. and Singh, V.P. 1992. Studies on correlation coefficients and path coefficient analysis in mungbean (*Vigna radiata* (L.) Wilczek). *J. Res. Haryana Agri. Univ.*, **21**(2) : 109-112.
- Sarma, R.N. and Talukdar, P. 1996. Causal relationships in micro mutants of greengram (*Vigna radiata* (L.) Wilczek). *Ann. agric. Res.*, **17** (1) : 38-41.
- Singh, K.P. and Singh V.P. 1995. Comparative role of seed yield components in mungbean. *Legume Res.*, **18** (20) : 109-112.
- Veerabadhiran, P. and Jehangir, K.S. 1995. Genetic variability, correlation and path analysis in greengram. *Madras Agric. J.*, **82**(5) : 364-367.

EFFECT OF INTEGRATED NITROGEN MANAGEMENT ON DRY MATTER, YIELD ATTRIBUTES, YIELD AND TOTAL N UPTAKE

R.A. JAT AND J.S. BALYAN

Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012

Maize (*Zea mays* L.) has a pivotal role among cereals in the world after wheat and rice. Maize is a traditional cereal grown mainly for human purposes though recently its industrial uses are steadily increasing. In past few decades replacement of maize from irrigated lands by photo-insensitive dwarf rice varieties is perhaps the main reason for low production of maize in north-eastern plains. Against the world average maize productivity of 4427 kg/ha, India's average yield is 2018 kg/ha certainly much lower. The scope to increase the area under maize is meager. Adoption of better crop production technologies and varietal improvement are the other alternatives for increasing the maize production.

Supporting the increasing population levels on a near stabilized agricultural land, which is a heavy burden on the soil resources. The degradation of soil fertility owing to over mining of nutrients and inadequate replenishment through fertilizers can only be curbed through adoption of INM (Paroda, 1998).

A comprehensive integrated nutrient package particularly for nitrogen is in need to boost the production and productivity of maize. Nitrogen is one of the primary plant nutrient elements which plays a vital role in plant system for the synthesis of protein, enzymes and nucleic acids which are responsible for the optimum development of chlorophyll and plant growth. Among the organic sources of plant nutrients, crop residue and FYM are of immense importance, the addition of which in general farming system may serve as a supplemental source of nutrients to help in economizing the use of fertilizers. Maize being a non-leguminous plant can derive advantage of the atmospheric nitrogen fixation through *Azospirillum*. However, the accrued benefits from this culture depends upon

many factors such as soil reaction, temperature, moisture and organic matter content. Keeping these points under consideration, the present investigation was taken up.

The experiment was conducted at New Delhi during kharif 2001. The soil was sandy loam, medium in organic carbon, available N, P and K. The treatments comprising two organic sources (crop residue incorporation @ 5 t ha⁻¹) as main plots and 8 sub plot treatments (0 kg N ha⁻¹, 50 kg N ha⁻¹, 50 kg N ha⁻¹ + Azo., 100 kg N ha⁻¹, 100 kg N ha⁻¹ + Azo., 150 kg N ha⁻¹, 150 kg N ha⁻¹ + Azo. and *Azospirillum* alone) were replicated thrice in split plot design. Crop residue incorporation was done in the form of wheat straw two months in advance of sowing while FYM was applied 10 days earlier. A composite of maize 'Vijai' was sown on 17 June, 2001 and harvested on 19 September, 2001. Nitrogen was applied in the form of urea ½ as basal, 1/3 at knee high stage and 1/3 at tasseling stage. Crop was grown under fully irrigated conditions.

Incorporation of crop residue along with FYM could not register any significant increase in any of the parameters undertaken for study in comparison of crop residue incorporation alone. This could be assigned to application of low amount of FYM and its negative impact on nitrogen fixation by *Azospirillum* (Nair, 2000 and Moharram et al., 1998).

Dry matter content, length of cob, no. of grains/cob, grain yield, stover yield and total N uptake were significantly higher with 150 kg N ha⁻¹ over all preceding treatments. However, N content and protein content in grain could increase significantly only up to 50 kg N ha⁻¹ + *Azospirillum*. While the effect of *Azospirillum* alone on all aforesaid parameters was on par with that of 50 kg N ha⁻¹. Similarly, the response

Table 1. Yield attributes, grain yield, stover yield, N content, protein and total N uptake under different treatments

Treatments	Dry matter per plant (g)	Length of cob (cm)	No. of grains/ cob	Grain yield (q/ha)	Stover yield (q/ha)	Grain N content (%)	Grain protein content (%)	Total N (kg/ha)
Organic sources of N								
Crop residue incorporation	125.87	16.84	277.12	41.25	70.30	1.59	9.62	111.95
Crop residue incorporation + FYM	130.75	17.20	282.56	42.81	72.10	1.67	10.82	116.75
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
N + Azospirillum								
0 kg N ha ⁻¹	111.81	15.60	240.67	31.56	59.44	1.46	9.12	79.35
50 kg N ha ⁻¹	122.21	16.48	271.64	37.66	65.75	1.59	9.83	99.97
50 kg N ha ⁻¹ + Azo.	129.61	17.21	284.21	42.90	72.55	1.67	10.43	118.07
100 kg N ha ⁻¹	131.59	17.24	287.69	43.94	74.10	1.68	10.50	121.97
100 kg N ha ⁻¹ + Azo.	132.41	17.26	288.41	44.41	75.56	1.69	10.56	124.91
150 kg N ha ⁻¹	139.14	17.99	300.38	49.33	81.40	1.71	10.68	138.88
150 kg N ha ⁻¹ + Azo.	139.59	17.99	300.40	49.33	81.50	1.71	10.68	138.95
Azospirillum alone	120.16	16.40	265.36	37.12	65.16	1.58	9.87	94.13
C.D. (P=0.05)	6.36	0.71	11.55	4.91	5.84	0.06	0.76	9.34

of 50 kg N ha⁻¹ + Azospirillum was at par with 100 kg N ha⁻¹. The inoculation with *Azospirillum* could prove significantly effective only with 50

kg N ha⁻¹ because higher amount of chemical fertilizer adversely affects its efficiency.

REFERENCES

- Moharram, T.M.M., H.M.A. and Safwat, M.S.A. 1998. Effect of *Azospirillum* inoculation on growth and N₂ fixation of maize subjected to different levels of FYM using ¹⁵N-dilution method. *Egyptian Journal of Microbiology*, 33(1): 1-15.
- Nair, A.K. 2000. Effect of farm yard manure and fertilizer levels on yield of maize (*Zea mays*) and succeeding rice bean (*Vigna umbellata*) crop in Sikkim. *Indian Journal of Agricultural Sciences*, 70 (4): 239-240.
- Paroda, R.S. 1999. National Resource Management of Sustainable Agriculture. A new paradigm Plenary Lecture. First International Agronomy Congress, New Delhi.

EFFECT OF VARIETY, SOWING TIME AND INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD ATTRIBUTES AND YIELD OF SUMMER MAIZE (ZEA MAYS)

SANJEEV MALAIYA, R.S. TRIPATHI AND G.K. SHRIVASTAVA

Indira Gandhi Agricultural University, Raipur, Chhattisgarh-492 012

A field experiment was conducted during summer season of 1999 and Indira Gandhi Agricultural University, Raipur (Chhattisgarh). The soil was sandy-loam (Inceptisols) low in available nitrogen (218 kg/ha), medium in available phosphorus (13.89 kg/ha) and medium in available potassium (289 kg/ha) with pH 6.9. The experiment was laid out in partial confounding design, replicated twice with 27 treatments combinations. The treatments consisted of three varieties (Mahyco-1765, ProAgro-3436 and Nutan-581), three date of sowing (April 22, May 2 and May 12) and three level of integrated nutrient management i.e. recommended dose of 120:60:40 kg N, P_2O_5 , K_2O /ha (F_{100}), 90 kg N/ha + 6 t FYM/ha + 45 kg P_2O_5 + 10 kg K_2O /ha ($F_{75}O_{25}$) and 60 kg/ha + 12 t FYM/ha + 30 kg P_2O_5 /ha ($F_{50}O_{50}$). Application of 6t FYM/ha supplied 30 kg N, 15 kg P_2O_5 and 30 kg K_2O /ha. The amount of N, P_2O_5 and K_2O was given in the form of urea, single super phosphate and muriate of potash, respectively. The row to row and plant to plant spacing was kept 50 cm $\times$ 20 cm using a seed rate of 25 kg/ha. The harvesting of green cobs were done twice and thrice at the time of grain filling stage.

The plant height was similar in all the varieties at 30 DAS but there was high rate of increase in plant height in all the varieties between 30 to 60th day and thereafter, there was marginal increase in plant height (Table 1). The stem diameter of all the varieties increased incrementally from 30 to 60 DAS and 60 DAS to harvest in all the positions. Variety ProAgro-3436 recorded the tallest plant and more girth and it was significantly higher than Mahyco-1765 and Nutan-581 both at 60 DAS and at harvest. It was interesting to note that variety ProAgro-3436

continued its girth elongation upto harvest and it was higher by 41.6% at top position and 49.3% at bottom of the stem than the girth increased between 30 to 60 DAS. However, at the top position, there was no difference in stem diameter in all the varieties during harvesting time. This might be due to genetic and morphological characteristics of varieties. The number of leaves weren't affected due to varieties at 30th day but at 60th day varieties Mahyco-1765 and ProAgro-3436 were at par and significantly higher than Nutan-581. While, at harvest, variety ProAgro-3436 had maximum number of leaves followed by Mahyco-1765 and Nutan-581. Leaf area index was significantly higher in Mahyco-1765 than ProAgro-3436 and Nutan-581 except at 60th day where Mahyco-1765 and ProAgro-3436 were at par (Table 2). The higher LAI is due to more green leaves even at harvest in Mahyco-1765. It is also confirmed as significantly positive correlation existed between LAI and number of leaves. In general, the formation and size of the leaves are governed by genetic characteristics as well as nutrient management and due to this different varieties behaved differently.

The plant height, number of leaves and LAI were also significantly less under April 22 seeding. The stored energy helped in increasing the diameter of stem. Similar finding was brought by Weaich *et al.* (1996) also. The plant height, leaf area and number of leaves increased at much higher rate in the plant grown on April 22 and May 2 as the favorable temperature and humidity was available during the month of May and June. In case of May 12 seeding, influence on above characters was at much slower rate as compared with observation of seeding to 30th days and 30 to 60th days. This might be due to

Table 3. Correlation matrix among growth, yield component and cob yield of summer maize

	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.763**	0.787**	0.158	0.224	0.633**	0.353	0.251	0.261	0.370	0.372	0.541**	0.349	0.782**
2		0.737**	0.234	0.210	0.551**	0.368	0.129	0.195	0.370	0.266	0.365	0.397*	0.630**
3			0.078	0.052	0.540**	0.583**	0.293	0.161	0.267	0.334	0.283	0.690**	0.775**
4				0.895**	0.407*	0.465*	0.333	0.488**	0.553**	0.581**	0.490**	-0.197	0.209
5					0.408*	0.403*	0.390*	0.374	0.463*	0.659**	0.574**	0.292	0.203
6						0.656**	0.528**	0.210	0.227	0.468*	0.745**	0.025	0.727**
7							0.682**	0.236	0.309	0.518	0.481*	0.341	0.665**
8								-0.080	-0.049	0.643**	0.377	0.150	0.415*
9									0.735**	0.177	0.375	-0.092	0.255
10										0.231	0.409*	-0.146	0.234
11											0.413*	0.050	0.405*
12												-0.282	0.690**
13													0.452*

* Significant at 5% level ** Significant at 1% level

Where,

1. Plant height at harvest, 2. No. of leaves at harvest, 3. Stem diameter top at harvest, 4. Stem diameter mid at harvest, 5. Stem diameter bottom at harvest, 6. LAI at harvest, 7. Dry matter at harvest, 8. Cob length, 9. Cob diameter, 10. Cob row no. 11, Grain/cob, 12. Harvest index, 13. Fodder yield, 14. Cob yield

favorable conditions available to the plant to achieve its normal morphological features.

The dry matter production at 40th day was significantly higher in Nutan-581 followed by ProAgro-3436 and Mahyco-1765, but the reverse was true at harvest stage (Table 2). This might be due to dwarf nature of Nutan-581. So it accumulated more dry matter at initial stage but at harvest stage other two varieties superseded in dry matter accumulation due to more plant height, stem diameter, number of leaves and LAI. The positive significant correlation in the study also confirmed the above statement (Table 3).

Variety Mahyco-1765 gave significantly higher cob yield and yield attributes (viz. length of cob, number of grain/cob, number of grain/cob and harvest index) as compared to ProAgro-3436 and Nutan-581 (Table 2). This may be due to genetical potential of varieties. Similar results have been reported by Shanti *et al.* (1997). The cob yield was higher in variety Mahyco-1765 due

to higher cob length (Pe'E and Camussi, 1982). Sowing on May 12 produced significantly higher cob and fodder yields with other yield attributes such as diameter of cobs, length of cob and number of grains/cob than earlier sowing on April 22 and May 2. In earlier sowing the turgidity of plant cells and cell elongation might be affected due to higher temperature, low humidity and higher solar radiation but May 12 sowing provided a suitable condition for growth and development of plant. Zaki *et al.* (1994) also concluded that cob yield increased with lateness of sowing but different dates of maize seeding affected the yield (Lourenco and Carolino, 1990) and cob length (Olsen *et al.* 1990). The application of 60 kg ha/ + 12 t FYM/ha + 30 kg P₂O₅/ha gave maximum cob yields, harvest index and number of rows/cob. Proper supply of major and micronutrients through integrated nutrient management was the main factor for increasing the cob yield. Similar findings were also reported by Faizabady *et al.* (1998).

Table 1. Effect of variety, sowing time and integrated nutrient management on growth of summer maize

Treatment	Plant height, cm			Stem diameter, cm						Number of leaves		
	30 DAS	60 DAS	At harvest	30 DAS			60 DAS			30 DAS	60 DAS	At harvest
	Top	Bottom	Top	Top	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	
Variety												
Mahyco-1765	23.27	170.46	173.97	0.69	1.37	0.72	1.49	1.53	1.14	1.70	1.89	6.02 11.30 9.26
ProAgro-3436	22.71	172.06	177.45	0.77	1.36	0.83	1.63	1.76	1.09	1.89	2.03	6.08 11.18 9.83
V ₃ - Nutan-581	23.26	151.44	160.61	0.67	1.31	0.67	1.38	1.46	1.04	1.63	1.72	6.17 09.94 8.59
Seeding time												
April 22	13.81	131.92	148.99	0.94	1.07	0.73	1.64	1.72	0.74	1.77	1.94	5.69 10.73 8.23
May 2	18.89	170.78	173.78	0.62	1.26	0.73	1.45	1.54	1.07	1.73	1.87	4.46 10.64 8.82
May 12	36.53	189.25	191.27	0.57	1.71	0.75	1.41	1.50	1.47	1.72	1.82	8.12 11.04 10.63
Integrated Nutrient Management												
F ₁₀₀	23.72	165.08	170.32		1.33	0.71	1.45	1.55	1.09	1.73	1.84	6.28 10.81 9.17
F ₇₅ O ₂₅	23.73	160.46	169.53	0.70	1.39	0.77	1.50	1.61	1.15	1.72	1.86	6.27 10.69 9.34
F ₅₀ O ₅₀	21.78	168.43	172.17	0.74	1.32	0.73	1.55	1.60	1.04	1.77	1.94	5.73 10.92 9.16
CD (P=0.05)	0.69	0.51	1.88	0.69	0.01	0.16	0.03	0.05	0.05	0.14	0.05	0.32 0.18 0.26

Table 2. Effect of variety, sowing time and integrated nutrient management on growth, yield attributes and yield of summer maize

Treatment	Leaf area index			Dry matter accumulation, (g/plant)	Diameter of cob (cm)	Length of cob (cm)	Rows (no.)	Grains /row (No.)	Cob yield, (q/ha)	Forage yield, (q/ha)	Harvest index (%)
	30 DAS	60 DAS	At harvest								
	Top	Bottom	Top	40 DAS	60 DAS	At harvest					
Variety											
Mahyco-1765	0.81	2.63	2.35	5.40	121.32	4.41	19.15	13.03	395.71	177.20	428.14 29.2
ProAgro-3436	0.70	2.52	2.01	6.51	104.74	4.79	16.00	15.16	363.68	158.76	389.57 29.07
V ₃ - Nutan-581	0.75	1.69	1.39	7.47	101.04	4.39	16.72	13.18	335.68	133.36	476.37 21.24
Seeding time											
April 22	0.44	2.00	1.71	1.48	99.81	4.46	17.06	13.51	343.98	112.17	328.23 25.73
May 2	0.43	2.15	1.72	4.08	101.13	4.63	17.05	14.11	373.64	156.65	447.41 25.85
May 12	1.39	2.70	2.32	13.81	126.14	4.50	17.76	13.75	377.44	200.50	518.45 27.94
Integrated Nutrient Management											
F ₁₀₀	0.80	2.13	1.87	6.32	105.81	4.57	17.65	13.63	366.58	147.79	432.91 25.54
F ₇₅ O ₂₅	0.82	2.24	1.75	7.67	110.38	4.56	17.16	13.63	362.26	158.43	447.75 25.73
F ₅₀ O ₅₀	0.64	2.47	2.12	5.39	110.91	4.46	17.07	14.12	366.23	163.10	413.41 28.24
CD (P=0.05)	0.05	0.12	0.14	0.41	1.87	0.16	0.16	0.14	47.58	2.79	5.80 0.52

REFERENCES

- Faizababy, A.Z., Kooheki, A., Dhaliwal, G.S., Arora, R., Randhawa, N.S. and Dhawan, A.K. 1998. Evaluation of coventional and ecological cropping systems based on wheat in rotation with corn and sugerbeet. *Proceedings of an International conference on Ecological Agriculture : Towards Sustainable Development, Chandigarh, India, 15-17 November, 1997* : 341-346.
- Lourenco, M.E.V. and Caroline, F.M.R. 1990. Influence of sowing date on maize. *Revistar de Ciencias Agrarias*. 13(2) : 19-25.
- Olsen, J.K., Blight, G.W. and Gillespie, D. 1990. Comparison of yield, cob characteristics and sensory quality of six supersweet (Sh2) corn cultivars grown in a subtropical environment. *Australian J. Experimental Agri.*, 30(3) : 387-393.
- Pe'E and Camussi, A., 1982. Yield components and plant traits in summer-sowing maize. *Maydica*, 27(3) : 169-183.
- Shanti, K., Rao, V.P., Reddy, M.R. and Sharma, P.S. 1997. Response of hybrid and composite maize to different levels of nitrogen. *Indian J. Agric. Sci.*, 67(8) : 326-327.
- Weaich, K.; Bristow, K.L. and Cass, A. 1996. Modeling pre-emergent maize shoot growth : II High temperature stress conditions. *Agron. J.* 88(3) : 398-403.
- Zaki, M.S., Paigham Shah and Shaukat Hayat, 1994. Effect of date of sowing on maize and non-flooded land Rice, *Sarhad J. Agric.*, 10(2) : 191-199.

INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON GROWTH AND YIELD OF SCENTED RICE (*ORYZA SATIVA* L.)

SANTOSH KUMAR JHA, R.S. TRIPATHI AND SANJEEV MALAIYA

Department of Agronomy
Indira Gandhi Agricultural University, Raipur-492012 (C.G.)

A field experiment was conducted during kharif season of 2000 at Indira Gandhi Agricultural University, Raipur (Chhattisgarh). The experiment was performed on sandy-loam (*Inceptisols*) having low nitrogen, medium phosphorus and high potassium with neutral soil reaction. The 12 treatments i.e. T_1 - $N_0P_0K_0$ (Control), T_2 - inorganic fertilizer 60:40:30 kg NPK/ha ($N_{60}P_{40}K_{30}$), T_3 - inorganic fertilizer 50 : 30 : 15 kg NPK/ha ($N_{50}P_{30}K_{15}$), T_4 - organic manure FYM 10 t/ha alone (FYM 10 t/ha), T_5 - combination of organic and inorganic 60 : 40 : 30 kg NPK/ha along with FYM 5 t/ha ($N_{60}P_{40}K_{30}$ + FYM₅), T_6 - 30:20:15 kg NPK/ha along with 5t/ha FYM ($N_{30}P_{20}K_{15}$ + FYM₅), T_7 - 30 kg N/ha in combination of poultry manure 2t/ha ($N_{30}P_0K_0$ + PM₂), Cow dung urine mixture was used in the present experiment alone or with the blending of inorganic fertilizer T_8 - Cow dung urine mixture 4 t/ha alone (CDU₄), T_9 - 50:40:30 kg NPK/ha blended with cow dung urine mixture 3t/ha ($N_{50}P_{40}K_{30}$ + CDU₃), T_{10} - 30:20:15 kg NPK/ha blended with cow dung urine mixture 3t/ha ($N_{30}P_{20}K_{15}$ + CDU₃), T_{11} - 30:20:15 kg NPK/ha blended with 1.5 t/ha cow dung urine mixture and green manure 5 t/ha was applied ($N_{30}P_{20}K_{15}$ + CDU_{1.5} + GM₅), T_{12} - 30:20:15 kg NPK/ha blended with 1.5 t/ha cow dung urine mixture along with lime 1q/ha ($N_{30}P_{20}K_{15}$ + CDU_{1.5} + L_{0.1}). The Randomized Block Design was followed with three replication and twelve treatments. Pusa Basmati-I cultivar of rice was taken as test crop.

Results indicates that application of inorganic fertilizer @ 30 kg N/ha along with 2t/ha of poultry manure significantly increased the plant height at 50 days after transplanting (Table 1). The inorganic fertilizer application of 30:20:15

kg NPK/ha in combination with either 3t/ha of cow dung urine mixture (CDU) or 1.5 t/ha of CDU + 5 t/ha of GM or 60:40:30 kg NPK/ha applied through inorganic fertilizer alone produced the similar plant height. This indicated that supply of nutrients under these treatment were sufficient to meet the demand of the crop and thereby maintained the similar plant height. However, when lower doses of nutrients applied through chemical fertilizer and supplemented with above organic manures, the availability of nutrients was enhanced and helped in increase plant height. The increased plant height due to application of these nutrients provided space for the formation of new leaves and thus leaves were also increased. The results are in agreement with the findings of Zodhy *et al.* (1984). The increased number of leaves enhanced the leaf area index. The correlation and regression study also indicated the significant positive correlation between these characters (Table 2). These results are in agreement with the finding of Sreedevi and Sreedharan (1999).

The application of nutrients either through inorganic fertilizer or lower level of nutrients blended with cow dung urine mixture helped in increasing the nutrient availability probably due to minimum loss of nutrients and increased the number of tillers/hill in comparison to control. The application of either 30 kg N/ha (inorganic fertilizer) with 2t/ha poultry manure or any levels of inorganic N, P and K supplemented with cow dung urine mixture i found to be equally effective for the production of tillers/hill at 30 DAT. The application of cow dung urine mixture along with inorganic nutrients release the nutrients at early stage, which was available to the crop at this stage. Further, increase in crop

Table 1. Effect of integrated nutrient amnagement on growth and yield of scented rice

Treatments	Plant height (cm)			Leaf area index			Number of tillers /hill			Dry matter accumulation (g/plant)			Effective tillers/m ²			Yield (q/ha)		Harvest index
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT	Grain	Straw	
T ₁ : N ₀ P ₀ K ₀	56.60	65.20	75.30	0.84	1.02	1.02	4.10	5.24	6.25	2.40	6.30	14.00	18.00	152.66	25.40	43.40	36.90	
T ₂ : N ₆₀ P ₄₀ K ₃₀	63.33	88.33	97.16	1.06	1.24	1.24	5.05	6.00	7.25	2.60	7.90	17.90	23.90	186.33	32.10	55.20	36.60	
T ₃ : N ₅₀ P ₃₀ K ₁₅	61.10	71.02	80.13	0.95	1.20	1.20	4.87	5.45	6.35	2.60	7.20	17.30	22.50	181.66	31.30	53.90	36.70	
T ₄ : FYM ₁₀	59.40	73.20	82.16	1.08	1.40	1.40	5.37	5.70	6.50	2.60	7.90	17.80	23.00	201.00	34.50	52.80	39.50	
T ₅ : N ₆₀ P ₄₀ K ₃₀ + FYM ₅	56.80	83.21	98.50	1.86	2.52	2.52	5.25	9.25	10.12	3.60	9.10	22.50	27.80	260.00	43.20	64.80	40.00	
T ₆ : N ₃₀ P ₂₀ K ₁₅ + FYM ₅	58.20	85.13	95.63	1.26	1.83	1.83	5.97	6.50	7.35	2.90	8.20	18.20	26.00	220.00	38.60	61.20	38.80	
T ₇ : N ₃₀ P ₀ K ₀ + PM ₂	60.33	93.93	100.23	1.53	2.50	2.50	6.82	8.10	8.90	3.40	8.90	21.60	26.60	240.66	41.80	63.50	39.70	
T ₈ : CDU ₄	61.67	82.37	90.57	0.88	1.12	1.12	4.50	5.37	5.86	2.60	6.70	18.20	21.20	163.00	27.30	51.50	34.60	
T ₉ : N ₅₀ P ₄₀ K ₃₀ + CDU ₃	58.07	84.97	95.37	1.25	1.90	1.90	6.12	7.60	8.30	3.00	8.40	19.40	25.50	235.00	38.50	59.60	39.20	
T ₁₀ : N ₃₀ P ₂₀ K ₁₅ + CDU ₃	58.23	88.12	96.80	1.19	1.80	1.80	5.80	6.12	7.20	2.80	8.00	18.20	24.20	207.00	35.10	5.90	37.70	
T ₁₁ : N ₃₀ P ₂₀ K ₁₅ + CDU _{1.5} + GM ₅	56.27	93.80	93.10	1.40	2.30	2.30	6.25	7.62	8.23	3.00	8.70	20.20	26.20	222.00	39.10	62.50	38.50	
T ₁₂ : N ₂₀ P ₂₀ K ₁₅ + CDU _{2.5} + L _{0.1}	60.03	83.53	90.83	1.10	1.51	1.51	5.50	5.92	7.12	2.60	7.80	17.50	22.60	206.33	30.30	53.60	36.10	
SEm±	-	1.99	1.11	0.06	0.09	0.09	0.46	0.45	0.27	0.006	0.23	0.56	0.42	11.50	1.01	1.28	0.74	
C.D.(5%)	NS	5.83	3.26	0.16	0.29	0.29	1.35	1.25	0.87	0.010	0.66	1.66	1.21	33.72	2.96	3.75	2.12	

age to 70 DAT, application of inorganic fertilizer of 60:40:30 kg NPK/ha along with 5 t/ha of FYM found to be better than other treatments. The 5t FYM released 26 kg N, 8 kg P and 24 kg K, besides many micronutrients and application of inorganic fertilizer 60:40:30 kg NPK/ha helped to mitigate crop requirement and thus this treatment assisted in increasing tillers/hill. Increased plant height and leaf area index helped in increasing the photosynthetic area for photosynthesis in plant, which in turn, helped in formation of new tillers. The beneficial effect of FYM to increase tillers of rice plant has been also reported by Patel *et al.* (1996). Budhar *et al.* (1991) and Zia *et al.* (1992). The dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increase the plant growth with respect to increased plant height, leaf area and tillers/hill etc. The treatments, which attained the maximum growth, also accumulated the higher dry matter at different growth stages.

The inorganic fertilizer application of 60:40:30 kg NPK/ha supplemented with FYM 5 t/ha produced the highest dry matter at all the stages, which was comparable to that of inorganic fertilizer 30 kg N/ha supplemented with poultry manure 2t/ha. Treatments provided sufficient nutrient for proper growth and development. Moreover, Balance nutrient supply was maintained where combination of organic and inorganic fertilizers were applied, which increased plant height, leaves and tillers and

contributed to enhance the dry matter accumulation. This fact was also confined from significant positive correlation between these characters. The lower dose of inorganic fertilizer combined with organic manure was as effective as higher dose of inorganic fertilizer alone for dry matter accumulation. Similarly, dry matter obtained at all the stages with the application of nutrient was superior to that of control (Singh *et al.*, 1998).

The increase in yield attributes significantly increased the grain yield. The inorganic fertilizers application of 60 : 40 : 30 kg NPK/ha in combination with 5t/ha of FYM or inorganic fertilizer of 30 kg N/ha applied along with 2t/ha of poultry manure were found equally effective for grain yield. The earlier treatment produced 70 per cent more grain yield than that of the control. These treatments were closely followed by application of inorganic fertilizer 30:20:15 kg NPK/ha supplemented with 1.5 t/ha of CDU and 5t/ha green manure. However, inorganic fertilizer of 50:40:30 NPK/ha supplemented with 3t/ha of cow dung urine mixture produced significantly higher grain yield when compared with application of inorganic fertilizer alone. It is well known fact that blending of N with cow dung urine mixture helps in continuous supply of the nutrients, reduced the nutrient loss and enhanced the nutrient use efficiency and grain yield over higher doses of inorganic fertilizer applied alone.

REFERENCES

- Budhar, M.N., Palaniappan, S.P. Rangaswamy, A. 1991. Effect of Farm Water and green manures on lowland rice. *Indian J. of Agron.*, **36** (2) : 251-252.
- Panda, D. and Singh, D.P., 1996. Integrated nutrient management for rice. In : Abstract of the International Symposium on Rainfed Rice for sustainable food security, Central Rice Research Institute, Cuttack, India, 23-25, September, 1996, pp. 49-51.
- Patel, M.S., Patel, M.L. and Goswami, K.P. 1996. Integrated nutrient management in paddy wheat cropping system in coastal salt affected soils of BHAL of Gujarat. In Abstract of the National Seminar on Organic Farming and sustainable Agriculture, 9-11 October, 1996, pp. 76-77.
- Singh G.R.; Prasad, J., Parihar, S.S. 1998. Integrated nutrient management in rice-wheat crop rotation *Advances in Plant Sciences*, **11** : 1, 175-178.
- Sreedevi, P. and Sreedharan, C. 1991. Performance of medium duration rice as influenced by plant population and fertilizer levels. *Agricultural Research Journal of Kerala*, **29** : 9-14.
- Zia, M.S., Munsif, M., Aslam, M. and Gill, M.A. 1992. Integrated use of Organic manures and inorganic fertilizers for the cultivation of lowland rice in Pakistan. *Soil Science and Plant Nutrition*, **38** (2) : 331-338.
- Zodhy, L.L.; Badr El-Din, S.M.S.; Khalah, M.A. and Abd E.L. Mak Nud, H.K. 1984. Evaluation of digested slurry as a fertilizer. *Egypt. J. Microbiol.*, **19** : 131-138.

EFFECT OF N,P,K AND S COMBINATIONS AND MICROBIAL INOCULANTS ON NODULATION, YIELD AND NP CONTENT OF SOIL AFTER HARVEST OF SOYBEAN [GLYCINE MAX (L.) MERRIL]

B.L. MENARIA AND PUSHPENDRA SINGH

Department of Agronomy
Rajasthan College of Agriculture
Maharana Pratap University of Agriculture and Technology
Udaipur-313 001

The field experiment was conducted during kharif 2000, as Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The treatment consist of four nutrient combinations (control, $N_{20} + P_{40}$, $N_{20} + P_{40} + K_{20}$, $N_{20} + P_{40} + K_{20} + S_{40}$ kg ha⁻¹) and four biofertilizer treatments [(control, *Bradyrhizobium japonicum*, phosphate solubilizing bacteria (PSB) and *Bradyrhizobium japonicum* + PSB]. The soil of experimental field was clay loam in texture with bulk density of 1.38 mgm⁻³, medium in available nitrogen (285.68 kg ha⁻¹), available phosphorus (29.35 kg P₂O₅ ha⁻¹), available potassium (256.64 kg K₂O ha⁻¹) and sulphur (10.01 ppm). The experiment was planned in Factorial Randomized Block Design with four replications. The nutrient content of soil after harvest were estimated with standard methods.

The results revealed that application of fertilizers had a positive effect on nodulation. The application of $N_{20} + P_{40}$ kg ha⁻¹ though increased nodules/plant over that of no fertilizer application but the extend failed to attained significance. However, application of $N_{20} + P_{40} + K_{20}$ and $N_{20} + P_{40} + K_{20} + S_{40}$ kg ha⁻¹ tended significant increase in nodules/plant by 9.69 and 15.80 per cent that produced under no fertilizer application (25.69 nodules/plant). The positive effect of increasing levels of nutrient combination on nodulation in soybean seems to be on account of balanced availability of nutrient in soil rhizosphere. This might have positively affected growth of microbes, thereby, formation of nodules. The results are in close agreement with Pal et al. (1996) and Cheng et al. (1999) [Table 1]. Increasing nutrient in combination significantly

increased seed and stover yield of soybean over their controls. The extent of increase in yield parameters with the application of $N_{20} + P_{40} + K_{20} + S_{40}$ kg ha⁻¹ were 37.36 and 29.74 per cent, respectively over their controls. In comparison to fertility status of unfertilized plots, plots fertilized with $N_{20} + P_{40} + K_{20} + S_{40}$ kg ha⁻¹ had significantly higher available N and P content after harvest of the crop.

The crop inoculated with *Bradyrhizobium japonicum* + PSB recorded significantly higher nodules (30.85/plant) representing increase by 25.13 per cent over no inoculation. But it was at par with *Bradyrhizobium japonicum* inoculation alone. The results are in close agreement with Gour (1985) and Subba Rao (1984). The crop raised under the influence of *Bradyrhizobium japonicum* and *Bradyrhizobium japonicum* + PSB inoculant significantly increased seed yield by 8.36 and 10.67 per cent over no inoculation. While, PSB was at par with control. However, seed inoculant with any inoculation produced significantly higher stover yield of soybean over control. The greater availability of nutrients in the soils and better nodulation under the influence of inoculation resulted in better growth and development and ultimately yield in soybean (Balamurugan and Gunasekaran, 1996). In comparison to fertility status of the soil under no inoculation, *Bradyrhizobium japonicum* + PSB treated plots had highest available N and P content in soils (370.10 kg N and 37.83 kg P₂O₅ ha⁻¹). Between single inoculant, *Bradyrhizobium japonicum* proved superior in improving available N status of soil over PSB, but for available phosphorus, PSB proved superior over *Bradyrhizobium japonicum*.

Table 1. Effect of N,P,K and S combinations and microbial fertilization on nodulation, yield and N,P content of soil after harvest of soybean crop

Treatment	Nodules/ plant at 60 DAS	Seed yield (q/ha ⁻¹)	Stover yield (q/ha ⁻¹)	Available N (kg/ha ⁻¹) (kg/ha ⁻¹)	Available P ₂ O ₅
NPKS Combinations :					
Control	25.69	14.99	18.09	349.82	30.38
N ₂₀ + P ₄₀	26.50	17.88	20.56	258.32	34.75
N ₂₀ + P ₄₀ + K ₂₀	28.25	19.24	21.90	260.18	36.22
N ₂₀ + P ₄₀ + K ₂₀ + S ₄₀	29.75	20.59	23.47	269.32	36.67
SEmt	0.562	0.442	0.502	1.745	0.610
CD at 5%	1.60	1.26	1.43	4.97	1.74
Microbial fertilizers :					
Control	23.12	17.06	19.57	350.38	31.98
Bradyrhizobium	29.88	18.49	21.38	361.61	32.08
Japonicum					
PSB	26.31	18.26	21.03	355.55	36.11
Bradyrhizobium	30.88	18.88	28.04	370.10	37.83
Japonicum+PSB					
SEmt	0.562	0.442	0.502	1.745	0.610
CD at 5%	1.60	1.26	1.43	4.97	1.74

REFERENCES

- Balamurugan, S. and Gunasekaran, S. 1996. Effect of combined inoculation of *Rhizobium* spp. and phosphobacteria at different levels of phosphorus in groundnut. *Madras Agric. J.* 83(8): 303-505.
- Cheng, G.H., Li, C.J., Jiang, G.M. and Zhoo, G.Z. 1999. Influence of main nutrient element on soybean yield. *J. Jilin. Agric. Univ.* 21(3): 68-70.
- Dubey, S.K. 1992. Effect of inoculation on soybean and the succeeding wheat crop at different levels of nitrogen. *Orissa J. Agric. Res.* 5(1-2): 30-53.
- Pal, T., Sounda, G., Dutta, D. and Panda, P.K. 1996. Residual effect of P and K on yield attributes, yield and oil content of groundnut. *Environ. Ecol.* 14(4): 583.

EFFECT OF LIMING ON AVAILABLE PHOSPHORUS AND MOLYBDENUM STATUS OF THE SOIL AFTER SOYBEAN

R. EBHIN MASTO*, G. BHUPAL RAJ, P. SURENDRA BABU AND K.S. JAYACHANDRAN

College of Agriculture
Acharya N.G. Ranga Agricultural University
Rajendranagar, Hyderabad-500 030

A pot experiment was conducted during Rabi 1999-2000 at Agricultural Research Institute, Rajendranagar, Hyderabad. Bulk surface soil sample (0-15cm) collected from Peduru village, Seethampeta mandal in Srikakulam district of Andhra Pradesh was used for this study. The soil was acidic having pH 5.7. The soil contained 222, 26.8 and 360 kg/ha N, P_2O_5 and K_2O respectively. Available Mo content of the soil was 0.83 mg/kg. The soil was sandy loam with low in organic carbon. The treatment consisted two levels of liming (0 and 3.5 t/ha based on lime requirement), two levels of P (0 and 10 mg P/kg and three levels of Mo (0, 0.25 and 0.5 mg Mo/kg). Phosphorus level (10 mg/kg) corresponds to 50 kg P_2O_5 /ha, which is being recommended for soybean. The trial was laid out in completely randomized design with factorial concept and replicated thrice. The test crop was soybean, variety JS-335. Analytical grade potassium dihydrogen phosphate and ammonium molybdate were the sources of P and Mo respectively. Pure $CaCO_3$ was the source of lime and it was applied to soil in powdered form at 21 days before sowing and mixed thoroughly with soil. The soil was subjected to many wetting and drying cycles before sowing. Soybean crop received uniform dose of nitrogen (30 kg N/ha) and potassium (40 kg K_2O /ha) through urea and potassium chloride respectively. Nitrogen and potassium doses were adjusted whenever the ammonium molybdate and potassium dihydrogen phosphate were used in the respective treatments. All nutrients were applied as basal dose in solution form before sowing.

*Present Address : Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi-110 012

Soybean seeds treated with *Rhizobium* were sown in the pots during the first fortnight of February 2000. Soil samples were collected from the individual pots after the harvest and were processed and analyzed for available P and Mo. The available soil 'P' and 'Mo' content was estimated by Olsen's method (Olsen et al., 1954) and ammonium oxalate method (Grigg, 1953).

Data on available P and Mo contents are presented in Table 1. Liming @ 3.5 t/ha significantly increased the available P from the initial value of 5.22 mg/kg to 10.56 mg/kg, which may be due to the favorable effect of lime on available P by enhancing the mineralisation of organic P and release of P from iron and aluminium bounded P fractions. Phosphorus application increased P content to 11.17 mg/kg. Similarly the Mo treatment also increased the P status and the phosphorus contents were 9.55 mg/kg and 10.58 mg/kg with 0.25 and 0.5 mg/kg Mo respectively. The desorption of P by replacing effect of molybdate (MoO_4^{2-}) from the soil colloidal complexed through anion exchange phenomena might have increased the available P content (Basak et al., 1982). The lime x P, lime x Mo, P x Mo and lime x P x Mo interactions were also significant in increasing the soil available Phosphorus. Along with the nutrient treatments, soybean rhizosphere secretions and exudates also possibly have contributed to P release. Molybdenum content in post harvest soil significantly increased to 0.241 mg/kg from the initial value of 0.083 mg/kg with liming. Similar results were reported by Kotur (1994) and Aghastise and Tayo (1994). The increase in Mo content may be attributed to the release of MoO_4^{2-} from soil complex in exchange for OH^- .

Table 1. Effect of molybdenum (Mo), phosphorus (P) and lime (L) on post harvest status in available P and Mo in soil

Treatments (mg/kg)	Phosphorus (mg/kg)					Molybdenum (mg/kg)				
	L ₀	L ₁	P ₀	P ₁₀	Mean	L ₀	L ₁	P ₀	P ₁₀	Mean
Mo-0.00	8.11	9.33	7.03	10.42	8.72	0.098	0.158	0.122	0.135	0.128
Mo-0.25	8.36	10.74	7.98	11.12	9.55	0.149	0.217	0.158	0.208	0.183
Mo-0.50	9.54	11.63	9.19	11.98	10.58	0.285	0.348	0.293	0.341	0.317
Mean	8.67	10.56	8.06	11.17	-	0.178	0.241	0.191	0.228	-
	L ₀ P ₀	L ₀ P ₁₀	L ₁ P ₀	L ₁ P ₁₀	Mean	L ₀ P ₀	L ₀ P ₁₀	L ₁ P ₀	L ₁ P ₁₀	Mean
Mo-0.00	5.82	10.04	8.23	10.43	8.72	0.089	0.107	0.154	0.162	0.128
Mo-0.25	6.15	10.57	9.81	11.66	9.55	0.122	0.176	0.193	0.240	0.183
Mo-0.50	7.39	11.69	10.98	12.27	10.58	0.243	0.327	0.343	0.354	0.317
Mean	6.46	10.89	9.68	11.46	-	0.152	0.203	0.230	0.252	-

L₀ and L₁ are no lime and liming @ 3.5 t/ha; (Initial soil test values P : 5.22 mg/kg, Mo : 0.083 mg/kg)

L₀ and L₁ are no lime and liming @ 3.5 t/ha; (Initial soil test values P : 5.22 mg/kg, Mo : 0.083 mg/kg)

CD (P=0.05)

	P	Mo
Line (L)	0.054	0.0021
Phosphorus (P)	0.054	0.0021
Molybdenum (Mo)	0.066	0.0026
L × P	0.076	0.0030
L × Mo	0.093	0.0037
P × Mo	0.093	0.0037
L × P × Mo	0.131	0.0052

in soil solution at higher pH values attained by liming. The formation of CaMoO_4 , a compound of higher solubility, also might have contributed to rise in available Mo status. Mo levels of 0.25 and 0.5 mg/kg significantly increased the Mo content to 0.183 and 0.317 mg/kg respectively. Phosphorus application increased Mo content to

0.228 mg/kg. The positive effect of P on Mo availability is due to the formation of complex phosphomolybdate anion (Barshad, 1951) and reduction in Mo sorption (Xie and Mackenzie, 1991). Highest soil Mo content of 0.354 mg/kg was observed with 0.5 mg/kg Mo plus 10 mg/kg P applied after liming.

REFERENCES

- Aghastise, V.O. and Tayo, T.O. 1994. *Indian J. Agric. Sci.*, **64** : 597-603.
- Barshad, I. 1951. *Soil Sci.*, **71** : 297-313.
- Basak, L.N., Mandal, L.N. and Halder, M. 1982. *Plant Soil*, **68** : 271-278.
- Grigg, I.C. 1953. *Newzealand J. Sci. Tech.*, **34** : 405-414.
- Kotur, S.C. 1994. *J. Indian Soc. Soil. Sci.* **42** : 613-621.
- Olsen, S.R., Cole, C.V., Watenable, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Cir. No. 939; Washington.
- Xie, R.S. and Mackenzie, A.E. 1991. *Geoderma*, **48** : 321-333.

GENETIC VARIABILITY AND ASSOCIATION BETWEEN PLANT HEIGHT AND BASE DIAMETER IN CAPSULARIS JUTE

NITENDRA PRAKASH, B.P. PANDEY, S.P. SINGH AND P.K. SINGH

Crop Research Station, N.D. University of Agriculture & Technology, Bahraich (U.P.)

Jute (*Corchorus capsularis*) is self pollinated crop, with some time as much as 10% out crosses. It requires humid and warm climate for growth. The plant height and base diameter are two important traits for fibre yield. Thus, the knowledge on the magnitude of genetic variability, correlation coefficient, heritability & genetic advance for these two characters in jute is essential for a breeder to select a superior parent for crop improvement. With the above objectives, an experiment involving 80 germplasm lines was conducted in a randomized block design with three replications at Crop Research Station, Bahraich (U.P.) during kharif 2000. Observations were recorded on five randomly selected plants of each genotype per replication for plant height and base diameter.

The analysis of variance was done from the mean data obtained for both the characters estimates of genetic parameters were computed as suggested by Johnsen *et al.* (1955). Phenotypic and genotypic correlation coefficient for both the characters were also estimated as suggested by Robinson *et al.* (1951).

The analysis of variance revealed highly

significant difference among genotypes for these two characters. The estimate of various genetic parameters are presented in Table (1). The phenotypic coefficient of variation was in general, higher than the genotypic coefficient of variation, which indicated role of environment in the expression of these two traits.

In the present investigation, the base diameter had high estimates of heritability high GCV and high GA % over mean while plant height showed high heritability, low GCV and low GA% over mean, high estimates of heritability (h^2) and genetic advance (GA%) was observed for base diameter. This may be due to positively additive gene action. However, plant height had high heritability coupled with low genetic advance indicating that this character was under influence of non additive gene action as was also reported by Mukewar *et al.* (1997) in Kneaf (*Hibiscus sabdreffa* L.). High heritability might be due environmental effect.

The genotypic correlation was slightly higher in magnitude than the phenotypic correlation indicating inherent association between height and base diameter in jute.

Table 1. Estimates of genetic parameters, phenotypic (P) and genotypic (G) correlations for two characters in capsularis jute

Character	PCV	GCV	GA (% over mean)	Heritability (%)	Genotypic correlated between plant height & base diam.	Phenotypic between plant height base diam.
Moisture conservation practices						
Plant height	5.38	5.14	10.11	91.3	0.42	0.39**
Base diameter	18.51	16.88	31.68	83.1		

REFERENCES

- Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. *Agron J.*, **47** : 314-318.
- Hukewar, J.S. Zone, J.S. and Lahane, P.S. 1997. *Indian J. Genet.*, **57** (2) : 161-162.
- Robinson, H.F.; Comstock, R.E. and Harvey, P.H. 1951. *Agron J.*, **43** : 282-287.

YIELD COMPONENTS OF CLUSTERBEAN AS INFLUENCED BY ZINC AND THIOUREA

KAVITA SHARMA, K.K. JAIN AND S.K. SHARMA

Department of Agronomy
College of Agriculture Rajasthan Agriculture University
Bikaner-334006

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] is an important kharif legume crop mainly grown under rainfed conditions in arid and semi arid regions of India. Due to its hardy nature and suitability to poor soils and moisture stress conditions, clusterbean is popularly grown in Rajasthan. The productivity of this region is very low (370 kg ha^{-1}) due to poor fertilizer management and growing this crop in marginal and sub marginal land as these are deficient in organic matter, nitrogen, phosphorous and zinc. Use thiourea as seed treatment and foliar spray has been reported to increase yield and yield attributes in pulses (Sharma *et al.* 2002). However there is lack of information on these aspects in clusterbean. Therefore, it was felt necessary to find out the response of clusterbean to zinc and thiourea.

A field experiment was conducted during kharif, 2001 at College of Agriculture, Bikaner (Rajasthan). The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), low in available nitrogen (66.03 kg ha^{-1}) & phosphorous (20.31 kg ha^{-1}) and medium in available potassium ($145.22 \text{ kg ha}^{-1}$) and zinc (0.78 ppm). The treatment comprised of five levels of zinc (0, 2, 4 and 8 kg ha^{-1}) and four modes of thiourea [Control (TUC), Seed soaking (TUS), Foliar spray at branching (TUB) and Seed soaking + Foliar spray at branching (TUS+b)]. Twenty treatment combinations were tested with three replications in randomized block

design. A clusterbean variety 'RGC-986' was sown on July 17th, 2001 at a spacing of 30 cm, Nitrogen @ 20 kg ha^{-1} and phosphorus @ 25 kg ha^{-1} were applied through urea and DAP, uniformly to all plots at the time of sowing. Zinc sulphate was applied as per treatment at the time of sowing. Seeds were soaked for 4 hours in 500 ppm thiourea solution in the case of seed treatment. Same concentration was used for foliar spray.

The results of the field experiment revealed that application of 4 kg Zn ha^{-1} gave significantly higher seed yield in comparison to control and 2 kg Zn ha^{-1} (Table 1). The increase in seed yield with the application of 2 and 4 kg Zn ha^{-1} was in the order of 17.37 and 7.05 percent over control and 2 kg Zn ha^{-1} , respectively. These variations in yield might be attributed to beneficial influence of zinc on pods per plant, grains per pod and test weight (Table 1). Similar results were reported by Mali *et al.* (2001).

The study further indicated that TUB significantly increased the yield attributes and yield of clusterbean over TUC. However, TUS treatment also increased the seed yield over control by 10.49 per cent. This might be due to beneficial effect of thiourea on seed germination, seedling growth, biomass production and better dry matter partitioning (Sharma, *et al.* 2002). Similar results have also been reported by Shekhawat (1998).

Table 1. Effect of zinc and thiourea on yield attributes and yield of clusterbean

Treatments	Yield attributes			Yield (q/ha)			Harvest index (%)
	No. of pods per plant	No. of seeds per pod	Test weight (g)	Seed	Straw	Biological	
Zinc levels (kg ha ⁻¹)							
Zn ₀	29.73	5.25	28.82	8.71	23.65	32.36	26.91
Zn ₂	31.43	5.75	29.97	9.78	25.91	35.69	27.40
Zn ₄	32.96	6.24	30.60	10.68	26.40	37.08	28.82
Zn ₆	33.66	6.44	30.56	10.60	26.90	37.50	28.26
Zn ₈	34.01	6.60	30.31	10.24	26.30	36.54	28.02
S.E.m.±	0.58	0.22	0.37	0.29	0.56	0.68	0.78
C.D. (P=0.05)	1.67	0.65	1.06	0.84	1.60	1.95	NS
Thiourea (500 ppm)							
TU _C	30.58	5.43	28.84	8.86	24.50	33.38	26.54
TU _S	31.97	5.87	29.95	9.79	25.26	35.05	27.93
TU _b	33.25	6.27	30.47	10.45	26.65	37.11	28.15
TU _S +b	33.34	6.66	30.95	10.91	26.93	37.84	28.83
S.E.m.±	0.52	0.20	0.33	0.26	0.50	0.61	0.70
C.D. (P=0.05)	1.50	0.58	0.95	0.75	1.43	1.75	2.01

NS = Non significant

REFERENCES

- Mali, G.C. Sharma, N.N; Acharya, H.K. Gupta, S.K. Gupta, P.K. 2001. Response of pigeonpea to sulphur and zinc fertilisation on vertisols in southeastern plain of Rajasthan. National Symposium on Arid Legumes for Food, Nutritional Security and Promotion of Trade: 109-110.
- Sharma, S.K., Shekhawat, B.S. and Jain, K.K. 2002. Faslon ke liye adhik upyogi thiourea. *Kheti*, 55(4) : 17-19.
- Shekhawat, B.S. 1998. Effect of levels and source of fertilizer, sulphur and thiourea application on growth, yield and quality of mustard (*Brassica juncea* (L.) Czern and Coss] in arid western Rajasthan. Ph.D. Thesis, Raj. Agril. Univ., Bikaner.

IDENTIFICATION OF TRAP CROPS FOR REDUCING OF BROOMRAPE (*OROBANCHE AEGYPTIACA*) INFESTATION IN THE SUCCEEDING MUSTARD (*BRASSICA JUNCEA*)

SUBHASH KUAMR*

Rajasthan Agriculture University,
Agricultural Research Station, Keshwana
Jalore-343001, Rajasthan

Mustard is an important crop of semi-arid zone of south-west Rajasthan. In the light soils of this region broomrape (*Orabanche aegyptiaca* Pers.), a parasitic weed, has been causing heavy losses in the mustard field. Broomrape being a holo-parasite emerges above the ground surface only 6 weeks after its germination on the root of host plant (Hosmani, 1993). Therefore, control methods which are employed after its appearance above the ground can only reduce the dispersal of seeds, but not the damage to the crop. Under such conditions broomrape infestation can be reduced by growing trap crops (Krishnamurthy and Chandwani, 1975). Therefore, the present investigation was undertaken with objective to identify the rainy season trap crops to reduce the infestation of the parasitic weed broomrape in the succeeding mustard crop.

A field experiment was conducted during rainy and winter seasons of 1997 and 1998 at the Agricultural Research Station, Keshwana, Jalore of the Rajasthan Agriculture University, Bikaner. There were thirteen treatments replicated three times in the randomized block design. These treatments comprised pure crops of blackgram (T-9), chillies (RCH-1), clusterbean (RGC-936), cowpea (RC-19), greengram (K-851), mothbean (RMO-40), pearl millet (Raj-171), sesame (RT-46), sorghum (local), sunhemp (K-12), weed free, broomrape-weedy and weedy. These crops were sown on 9-7-1997 with the recommended row distance of 30-45 cm. Chillies were transplanted on 29-7-1997. Blackgram, cowpea, clusterbean,

greengram, mothbean, and sunhemp were fertilized with 20 kg N and 40 kg P_2O_5 per hectare as basal dose. Pearl millet and sorghum were given 60 kg N + 40 kg P_2O_5 and sesame 40 kg P_2O_5 with 50% N and 100% P_2O_5 as basal and 50% N at 25 days after sowing. Crops were irrigated at 15, 25, 40 and 65 days after sowing (DAS) as need of the different crops. At the 45 DAS sunhemp was mixed in the soil as a green manure. Other crops were harvested after the maturity only and all plots were prepared manually without disturbing the layout. Then on 11-11-1997 mustard cv. Bio-902 was sown with 30 cm row spacing in all the plots and fertilized with 60 kg N and 40 kg P_2O_5 per hectare. 50% N and 100% P_2O_5 fertilizer were applied as basal and remaining 50% N top dressed at 28 DAS. Three irrigations were given to mustard at 25, 45 and 70 DAS. Thinning was done at 28 DAS to maintain the plant distance of 10 cm in all the plots of mustard crops.

Broomrape weed infestation (35 weeds/m²) on the mustard crop caused 28.2% average reduction in the yield (Table 1). The rainy season crops cowpea, blackgram, mothbean, sunhemp, clusterbean and sesame caused significantly less parasitism of broomrape and produced significantly higher yield of subsequently grown mustard crop when compared with control in the winter season. The reduction in the broomrape parasitism might be due to reduction in the seed bank as Krishnamurthy et al. (1977) reported that trap crops induce the germination of broomrape seeds and did not allow the parasite to develop beyond the filamentous stage. Hosmani (1985) also reported sunhemp, a potential trap crop for *Orobanche cernua*. Crops

* Present address : Biossay Division, Central Insecticides Laboratory, Directorate of P.P.Q. & S., NH-IV, Faridabad-121001, Haryana.

Table 1. Effect of trap crops on the Orobanche infestation and yield of succeeding mustard crop

Trap crop grown in rainy season	No. of broomrape plants per 10 m ² in mustard	Mustard yield (kg/ha)
Blackgram (<i>Vigna mungo</i> L.)	35.0 (5.9)*	979.7
Chillies (<i>Capsicum anum</i> L.)	200.0(13.6)	790.7
Clusterbean (<i>Cyamopsis tetragonoloba</i> (L.) Taub.)	74.0(8.46)	1062.0
Cowpea (<i>Vigna unguiculata</i> (L.) Taub.)	31.3(5.4)	1009.3
Greengram (<i>Phaseolus radiatus</i> L.)	259.3(16.1)	870.2
Mothbean (<i>Vigna acontifolia</i> L.)	56.7(7.05)	1013.0
Pearlmillet (<i>Pennisetum typhoides</i> (B.) S&H)	127.7(11.1)	870.4
Sesame (<i>Sesamum indicum</i> L.)	81.3(8.53)	970.4
Sorghum (<i>Sorghum bicolor</i> (LO.) Moench.)	39.0(18.16)	787.1
Sunnhemp (<i>Crotalaria juncea</i> L.)	68.0(8.10)	1309.2
Orobanche-Weedy	353(18.32)	800.0
Weed-free	0.0(1.0)	1114.8
Weedy	239(14.95)	716.7
C.D. (P=0.05)	(7.04)	244.3

* Figures in parentheses are square root transform values.

like sorghum, pearlmillet, chillies and greengram did not exhibit any substantial reduction in the infestation of broomrape and caused 21.9 to 29.4% reduction in mustard yield when compared with weed-free treatment.

Pre-seeding crop of cowpea, blackgram, mothbean, sunhemp, clusterbean and sesame may be grown as a trap crop in the rainy season for lesser infestation of broomrape on the mustard crop to fetch the higher yield.

REFERENCES

- Hosmani, M.M. Malipatil, T.B. and Hanumanthappa, M. 1993. In: *Orobanche and its control*. University of Agriculture Science, Dharwad, Karnataka, pp. 31.
- Krishnamurthy, G.V.G. and Chandwani, G.H. 1975. PANS 21(1): 64-66.
- Krishnamurthy, G.V.G. Nagrajan, K. and Lal, R. 1977. *Indian Journal of Weed Science*, 9: 95-106.
- Hosmani, M.B. 1995. Studies on control on *Orobanche* and *Striga* by trap crops. M.Sc. (Ag.) thesis, UAS, Dharwad, Karnataka.

NUTRIENT UPTAKE AND SEED QUALITY OF SPRING SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN MOLLISOLS OF UTTRANCHAL

M.S. PAL

Department of Agronomy, College of Agriculture
G.B. Pant Univ. of Agric. & Tech.
Pantnagar-263145, Uttranchal

Sunflower (*Helianthus annuus* L.) is a new attraction for farmers because it provides cholesterol free edible oil, easy to fit in to most of the cropping systems due to its early maturity, high yield, better economic returns and can be grown through out the year as it is a photo insensitive crop, hence number of hybrids have been bred for commercial cultivation. Presently, it is mainly grown during spring season in whole northern India and in kharif and rabi in southern India. Number of reports have been filed by local farmers for their poor yield, multi-heads and residual effects on succeeding crops, therefore, these hybrids, released particularly by multinational seed companies are required to be tested properly for their production potential and nutrient uptake capacity before recommending for commercial cultivation. Keeping these points in mind, the present field experiment was carried out to evaluate the production potential, seed quality and N, P and K uptake capacity of different hybrids during spring season in Mollisols of Uttranchal.

Field experiment was carried out during spring season of 1999 at crop Research Center, G.B. Pant University of Agriculture & Technology, Pantnagar. The experimental site was silty loam with soil pH, organic carbon, total nitrogen, available phosphorus and potassium were 6.75, 1.06%, 0.079%, 56 kg /ha and 374 kg/ha, respectively. The ten sunflower cultivars namely Morden (open pollinated), Sungene-85, Jwalamukhi, PSFH-67, MSFH-8, MSFH-51, NSFH-999, GK-2004, No-6460 and No-3301 were sown on 28th February under Randomized Block Design in three replications. All cultivars were

sown at 60 cm × 30 cm spacing with 8 kg/ha seed rate and 120, 60 and 40 kg N, P and K/ha, respectively. The half N and full P and K were applied as basal and remaining half N was applied in two equal doses at 25 and 45 days after sowing (DAS), respectively. The crop was protected from insects-pest by spraying of Endosulfan @ 1.5 ml/l water at 45 and 60 DAS. The dry matter accumulation, leaf area and yield attributes were observed at 25, 50, 75 DAS and at harvest. The seed oil was extracted with the help of soxhlet method and protein content by multiplying of N content in seed and 6.25.

The yield attributes, seed yield, harvest index, oil content and protein content differed significantly with cultivars. The highest head diameter was noticed in No-3301 that remained non-significant with MSFH-8 and NSFH-999. The highest head weight was recorded in MSFH-8 that was statistically at par with NSFH-999. All hybrids had higher head weight than Morden because of larger size and better seed setting. Kumar (1998) found that seed setting was more in hybrids than open pollinated cultivars. The 1000 seed weight was found greatest in MSFH-8 followed by NSFH-999, MSFH-51, No-3301 and No. 6460. Higher seed weight per plant was recorded in MSFH-8 that did not differ significantly with NSFH-999 and No. 3301. All hybrids had higher seed weight per plant than Morden because of higher head weight. Hybrid MSFH-8 gave significantly highest seed yield because of its higher yield attributes. Morden gave the lowest seed yield. Hybrid MSFH-8 gave 70% higher seed yield than Morden. Other hybrids namely NSFH-999, MSFH-51 and No.

Table 1. Effect of cultivars on head diameter, seed yield, harvest index, oil and protein content of sunflower

Cultivars	Head diameter (cm)	Head wt/plant (g)	Seed wt/plant (g)	1000 seed wt. (g)	Seed yield (kg/ha)	Harvest index (%)	Oil content (%)	Protein content (%)
Morden	17.83	103.33	46.33	47.23	1753	40.67	36.0	15.5
sungene-85	17.90	107.13	47.03	48.96	1853	38.56	40.2	16.0
Jawalamukhi	17.36	119.10	52.10	52.83	2158	32.86	41.5	17.0
PSFH-67	18.20	113.96	50.43	49.70	2063	33.83	41.3	16.8
MSFH-8	21.13	136.60	59.36	58.20	2973	32.83	43.3	19.2
MSFH-51	19.80	128.66	56.33	55.63	2679	31.82	40.5	18.5
NSFH-999	20.86	132.56	57.73	55.86	2852	31.96	43.2	19.0
GK-2004	19.50	122.60	51.13	53.03	2241	1.53	39.5	17.2
No.-6460	19.80	127.63	55.93	54.90	2432	31.73	40.7	17.3
No. 3301	21.23	130.93	57.86	55.09	2622	32.60	42.3	18.8
C.D. (0.05)	1.18	4.33	1.87	1.87	125	3.31	2.0	0.6

3301 also performed better and yielded 4.24, 10.97 and 13.34% lower seed yield than MSFH-8. The seed yield had significant positive correlation with head diameter ($r=0.921$), head weight ($r=0.978$) and 1000 seed weight ($r=0.963$).

The harvest index (HI) varied significantly among cultivars and Morden recorded higher HI 40.6% because it produced comparatively higher seed weight per plant. Among hybrids, Sungene-85 had higher HI 38.6 followed by PSFH-67, Jawalamukhi, No. 3301 and MSFH-51. The oil content and protein content differed significantly among cultivars. The highest 43.33%, No. 3301 42.26%, Sungene-85 42.23% and Jawalamukhi 41.50%. Significantly lowest value was recorded in Morden followed by GK-2004, MSFH 51, No. 6460 and PSFH-67. Hybrid MSFH-8 gave the highest protein content 19.16% which was statistically same with NSFH-999 and No. 3301. The lowest value was obtained in Morden that was significantly lowest than all other cultivars. Hybrid MSFH-8 had higher oil content because of bold seeds as it was found that oil content was positively correlated with head weight ($r=0.538$) and 1000 seed weight ($r=0.609$) (Fig. 1). Thosar et al. (1991) and Shafiullah et al. (1994) also reported significant differences in oil content among cultivars. The protein content varied with cultivars due to its genetic variation among cultivars and it was supported by Dhawan et al. (1983).

N, P and K content in seed and stalk were greatly influenced by sunflower cultivars (Table 2). All hybrids had greater N, P and K content in seed and also in stalk than composite Morden. Among hybrids, the highest N content in both seed and stalk was recorded in MSFH-8 that had non-significant difference with the values of NSFH-999 and No. 3301. The N content varied from 2.473 to 3.066% in seed and 0.533 to 0.95% in stalk. Composite Morden gave the lowest N content in seed as well as in stalk. Similarly, the highest P content in seed was observed in MSFH-8. All other hybrids had lower values of P content in both seed and stalk than MSFH-8. All other hybrids had lower values of P content in both seed and stalk than MSFH-8. The K content in seed was also recorded significantly highest

Table 2. Effect of cultivars on N, P and K content (%) in seed and stalk of sunflower in Mollisols of Uttaranchal

Cultivars	N(%)		P(%)		K(%)	
	Seed	Stalk	Seed	Stalk	Seed	Stalk
Morden	2.473	0.533	0.316	0.088	0.473	2.216
sungene-85	2.556	0.580	0.334	0.089	0.486	2.250
Jawalamukhi	2.726	0.620	0.341	0.093	0.526	2.276
PSFH-67	2.583	0.600	0.335	0.091	0.510	2.260
MSFH-8	3.066	0.696	0.376	0.104	0.623	2.376
MSFH-51	2.956	0.643	0.352	0.095	0.550	2.313
NSFH-999	3.040	0.6763	0.365	0.098	0.570	2.363
GK-2004	2.746	0.636	0.342	0.94	0.540	2.286
No.- 6460	2.763	0.643	0.347	0.094	0.0546	2.290
No. 3301	3.000	0.656	0.355	0.097	0.553	2.340
C.D. (0.05)	0.097	0.042	0.009	0.004	0.036	0.076

Table 3. Correlation of seed yield and oil content with head diameter, head weight and 1000 seed weight

S.No.	Character	Head diameter (cm)	Head weight (g)	1000 seed weight (g)
1	Seed yield	0.921**	0.978**	0.963**
2	Oil content	0.413	0.538	0.609
3	Head diameter	-	0.889**	0.847**
4	Head weight	-	-	0.987**

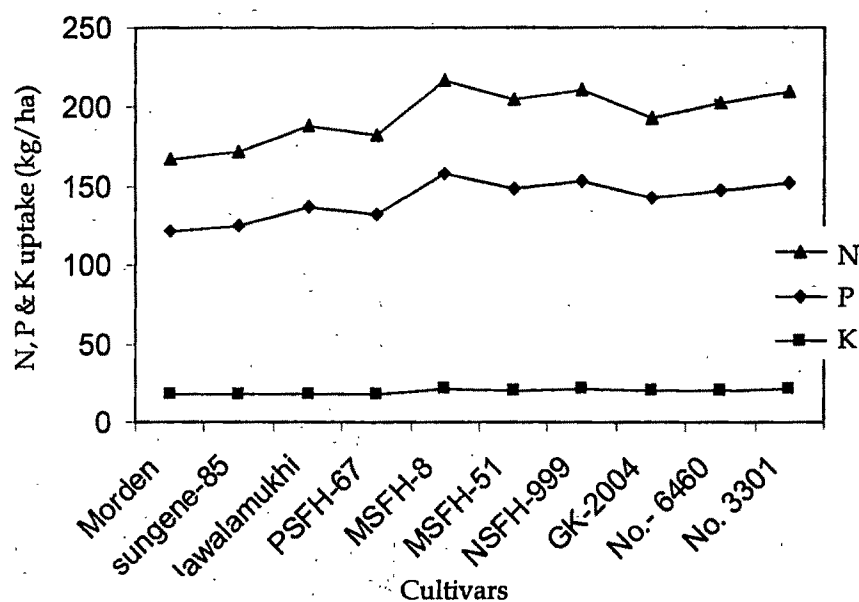


Fig. 1. Effect of cultivars on N, P and K uptake (kg/ha) of sunflower

in MSFH-8. The K content in stalk was significantly higher in MSFH-8, though it did not differ significantly with MSFH-51, NSFH-999 and No. 3301. Composite Morden had the lowest K content in both seed and stalk. Among hybrids, Sungene-85 gave the lowest N, P and K content in both seed and stalk. The N, P and K content in seed and stalk varied due to variation in their genetic constitution and nutrient accumulation capacity.

The pattern of N, P and K uptake was almost similar to N, P and K content in plant organs of

different sunflower cultivars (Fig. 1). Hybrid MSFH-8 and composite Morden gave significantly greatest and the lowest N, P and K uptake respectively except the N uptake that did not differ significantly between MSFH-8 and NSFH-999. Among hybrids Sungene-85 had the lowest N, P and K uptake followed by PSFH-67, Jwalamukhi, G.K. 2004 and No. 6460. The reason of higher uptake was the better growth and greater dry matter accumulation. Sarmah et al. (1995) reported difference in N, P and K uptake among cultivars.

REFERENCES

- Dhawan, K., Gupta, S.K. and Chhabra, M.L. 1983. Effect of date of sowing and variety on chemical composition of sunflower. *Indian J. Agric. Sci.*, **53** : 612-613.
- Kumar, A. 1998. Studies on the influence of sowing dates on photosynthesis, yield and oil content of spring sunflower (*Helianthus annuus* L.) cultivars. Thesis, M.Sc. G.B. Pant Univ. of Agric. & Tech., Pantnagar.
- Sarmah, P.C., Katyal, S.K. and Bhola, A.L. 1995. Nutrient uptake and quality of spring sunflower as influenced by fertility level and plant population. *Haryana Agril. Univ. J. Res.*, **25** : 21-28.
- Shafiullah, Rana, M.A., Yusaf, M., Mohanaud, A. S. and Ali, G.M. 1994. Effect of different planting dates on yield and yield components of sunflower (*Helianthus annuus* L.). *Crop Res. Hisar*, **24** : 199-206.
- Thosar, V.R., Kere, H.K., Kale, M.R., Ulemale, R.B. and Tatte, P.S. 1971. Effect of sowing dates on yield of sunflower (*Helianthus annuus* L.) varieties. *New Agriculturists*, **2** : 69-72.

ISSN 0970-3179



Annals of Agricultural Research

New Series Vol. 25

June 2004

Number 2

Published by
The Indian Society of Agricultural Science

INDIAN SOCIETY OF AGRICULTURAL SCIENCE
(Reg. No. S-10231)

EXECUTIVE COUNCIL

<i>Patron</i>	:	M.S. Swaminathan
<i>President</i>	:	Panjab Singh
<i>Vice-Presidents</i>	:	N.N. Singh
	:	R.G. Dani
<i>Secretary</i>	:	R.C. Gautam
<i>Joint Secretary</i>	:	D.S. Mathur
<i>Treasurer</i>	:	B.N. Mishra
<i>Past Presidents</i>	:	M.V. Rao, Prem Narayan,
	:	K.L. Chadha, R.B. Singh

COUNCILLORS

<i>East Zone</i>	<i>West Zone</i>
L.M. Garnayak, Orissa	M.V. Savani, Gujarat
A.K. Patra, Orissa	V.N. Waghmare, Maharashtra
<i>North Zone</i>	<i>South Zone</i>
N.K. Sekhon, Ludhiana	B.N. Reddy, Hyderabad
D.K. Pachauri, New Delhi	H.V. Nanjappa, Bangalore
<i>Central Zone</i>	
H.S. Yadav, M.P.	A.K. Pandey, U.P.

EDITORIAL BOARD

<i>Editor-in-Chief</i>	:	S.K. Mishra
------------------------	---	-------------

Editors :

<i>Crop Improvement:</i>	<i>Resource Management:</i>	<i>Crop Protection :</i>	<i>Basic Sciences:</i>	<i>Social Sciences:</i>
B. Sharma	R.K. Rai	Amerika Singh	R.K. Katiyar	R.P. Singh
P.K. Singh	A.K. Dahama	Pratibha Sharma	Rajender Parsad	Poonam Sharma
A.K. Singh	B.G. Shivakumar	Kirti Sharma	G.C. Srivastava	Prem Lata Singh
R.L. Misra	R.N. Garg	Chitra Srivastava	S.M.S. Tomar	A.K. Das
Rajeev K. Sharma	S.K. Singhal	Anil Sirohi	M.K. Rana	Suresh Pal

All correspondences should be addressed to **Dr. R.C. Gautam, Secretary, Indian Society of Agricultural Science, Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012.**

Membership	India	Foreign Air Mail
Annual	Rs. 250	US\$40
Life	Rs. 2500	US\$500
Institutional	Rs. 850	US\$250

Discount to publishers 10%

Subscription may be sent by bank draft only. Payable to "**Indian Society of Agricultural Science**" at New Delhi. Out-station cheques are not accepted.

ANNALS OF AGRICULTURAL RESEARCH

(Organ of the Indian Society of Agricultural Science)

To promote inter-disciplinary research in the field of agriculture and provide a forum for expressing views on policies and programmes relating to agricultural development

CONTENTS

		Page
P-Nutrition in rice-wheat cropping system with microbial consortia	B.D. Kaushik, B.N. Mishra, R.C. Gautam and A.K. Rana	179
Genetic diversity in performance per se and economic heterosis among newly developed A ₁ cytoplasmic male sterile lines and restorers in pearl millet	K.V. Unnikrishnan, Balzor Singh, Ramesh Singh, A.P.S. Verma and K.P. Singh	187
Effect of agronomic practices on growth and yield of rapeseed (<i>Brassica campestris</i> L.) spp. Oleifer (Metzger) Sinsk. var. yellow sarson	Arup Ghosh and Subhendu Mandal	192
Line x tester analysis for fodder yield and quality components in multicut forage sorghum	K. Iyanar and A.K. Fazlulul Khan	196
Stability analysis in french bean (<i>Phaseolus vulgaris</i> L.)	U.P. Pandey, G. Prashad and Sudhakar Pandey	200
Combining ability analysis for yield and its components in hybrid rice	Anand Kumar, N.K. Singh and V.K. Chaudhary	206
Index of drought resistance in relation to water retention parameters in bread wheat	S.S. Dhanda and G.S. Sethi	211
Cellulase activities and its correlation to yield in early and late strain of <i>Pleurotus</i> spp.	Madhurendra, N. Prasad and S.G. Sharma	215
AAMI analysis for grain yield stability of maize (<i>Zea mays</i> L.) hybrids	D.M. Reddy, V.P. Ahuja and B.K. Mukherjee	218
Studies on variability, heritability and genetic advance in pomegranate (<i>Punica granatum</i> L.) for yield and its contributing characters	K.K. Meena, Room Singh and S.K. Singh	223
Influence of preceding crops and fertilizer application on dry matter accumulation, biomass production and uptake of N and P by mustard [<i>Brassica juncea</i> (L.) Coss & Czern]	Bhartendu Mishra and Gajendra Giri	226

Fodder production potential of pure and intercropped cereal and legume forages under rainfed conditions	B. Gangaiah	229
Effect of nitrogen and zinc on wheat irrigated with alkali water	Y.P. Singh	233
Influence of aqueous leaf extract of ber on germination and seedling growth of cowpea and fenugreek	P.L. Saroj, C.K. Purohit, R. Bhargava and B.D. Sharma	237
Effect of integrated weed management on yield components, yield and economics of baby corn (<i>Zea mays</i>)	Subhendu Mandal, Subimal Mondal and Subhadeep Nath	242
Efficacy of different fungicides on the incidence of yellow rust (<i>Puccinia striiformis</i>) on wheat under cold arid conditions of Ladakh	V.K. Yadav, M.A. Wani, H.V. Singh and M.S. Mir	245
Stability analysis for performance of rainfed bread wheat (<i>Triticum aestivum</i> L.) genotypes	R.B. Yadav and H.B. Choudhary	248
Effect of foliar application of different sources of Zn on the changes in Zn content, uptake and yield of rice (<i>Oryza sativa</i> L.)	D.K. Das, Tanmoy Karak and Debtanu Maiti	253
Rainfall analysis and crop planning in Uttar Pradesh	A.K. Srivastava, C.V.S. Sastri and R.N. Garg	257
Response of applying <i>Acetobacter</i> bioculture to autumn sugarcane under intercropping with <i>Rhizobium</i> inoculated pea and frenchbean	S.C. Singh, S.N. Singh, V.C. Yadon and S.B. Singh	265
Evaluation of Punjab American cotton (<i>G. hirsutum</i> L.) genotypes for tolerant to high temperature and their performance during spring summer season	R.P. Singh, Jagmail Singh, C.B. Lal, Sunita and K. Elayaraja	268
Effect of tillage practices and irrigation schedules on performance of castor in rice fallows	P. Sesha Saila Sree, B. Bhaskar Reddy and P. Mary Kamala	274
Plant regeneration through somatic embryogenesis from germinated seed and coleoptile cultures of finger millet	M.S. Kamble, B.L. Dhonukshe, N.V. Kashid and G.N. Shirpurkar	278
Influence of planting ratio and fertilizer application on dry matter production LAI and nutrient content and uptake by maize (<i>Zea mays</i>) and groundnut (<i>Arachis hypogaea</i>) in intercropping	Arvind Kumar, S.N. Singh and Gajendra Giri	283
Effect of integrated nutrient supply on growth and yield of wheat (<i>Triticum aestivum</i>)	Suman Mehta	289
The socio-economic, communication and psychological characteristics of the sorghum growers in Vidharbha region in Maharashtra	V.N. Kardak, N.V. Kashid, M.S. Kamble and S.N. Kardak	292

CONTENTS

iii

Soil critical sulphur availability index for raya (<i>Brassica juncea</i> L.) in hill soils of north-west Himalayan region	<i>Rakesh Sharma and Jagat Ram</i>	297
Management of N and P in wheat + chickpea intercropping system on yield attributing characters and yield of chickpea under rainfed conditions	<i>Ajay Kumar and R.K. Singh</i>	300
Influence of irrigation levels and diclofop-methyl on weed growth and yield of wheat (<i>Triticum aestivum</i> L.)	<i>Rajbir Singh</i>	306
Evaluation of intercropping patterns of soybean (<i>Glycine max</i>)	<i>Ved Prakash, A.K. Pandey and A.K. Srivastva</i>	312
Studies on some growth parameters in Colocasia at different spacings	<i>Ira Sarma</i>	316
Effect of sources and levels of phosphorus with and without seed inoculation on the performance of rainfed chickpea (<i>Cicer arietinum</i> L.)	<i>B.G. Shivakumar, S.S. Balloli and C.S. Saraf</i>	320
Effect of integrated sources of nitrogen on yield of aromatic rices and their residual effect on succeeding wheat crop	<i>N.P. Adhikri and B.N. Mishra</i>	327
Effect of micronutrients fertilization on productivity potential of urdbean (<i>Phaseolus mungo</i> L.)	<i>P.K. Salam, R.S. Rajput, P.K. Mishra, Anita and G.K. Shrivastava</i>	329
Influence of sources and levels of phosphorus with and without phosphorus solubilizing bacteria (PBS) seed treatment on growth and yield of soybean (<i>Glycine max</i> L.)	<i>B.G. Shivakumar and S.N. Sidramappa</i>	333
Effect of date of sowing, row spacing and weed control practices on weed growth and productivity in soybean	<i>Dheeraj Pandey, Dheer Singh and P.K. Tomar</i>	335

P-NUTRITION IN RICE-WHEAT CROPPING SYSTEM WITH MICROBIAL CONSORTIA

B.D. KAUSHIK, B.N. MISHRA¹, R.C. GAUTAM¹ AND A.K. RANA

Division of Microbiology, Indian Agricultural Research Institute, New Delhi-110012

¹Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Results revealed that the yield of paddy and wheat were significantly higher due to inoculation with BGA, PSB and VAM at 30 kg P₂O₅ as SSP plus 30 kg P₂O₅ as URP over alone 30 kg P₂O₅ either as SSP or URP or control but at par with 60 kg P₂O₅ as SSP. The quality of grain and straw in terms of percentage of nitrogen and phosphorus were significantly superior to that of full dose of phosphorus as SSP, single inoculants or control. Soil health was improved in terms of carbon buildup, residual soil nitrogen and soil available phosphorus. Results have clearly demonstrated that 30 kg P₂O₅ as SSP can safely be replaced with 30 kg P₂O₅ as URP in presence of BGA, VAM and PSB as inoculant. An additional yield of paddy 1.91 q ha⁻¹ and wheat 2.31 q ha⁻¹ were obtained with a net saving of Rs. 2907 as phosphatic fertilizer input cost.

Key words : Phosphorus, rice-wheat system, microbial consortia.

Phosphorus been referred to as the 'master key element' in crop production as most of the phosphorus present is unavailable to plant, making fertilizer use efficiency low. A large number of microorganisms-actinomyces, yeast, fungi and bacteria have been found to dissolve insoluble or inoculated with pure cultures of phosphate dissolving microorganisms. Multilocal trials indicated that phosphate solubilizing bacteria (PSP) inoculation increased the yield of rice by 10-20% (Gaur, 1990). Blue green algae (BGA) biofertilizer for rice are better known to provide biologically fixed nitrogen and increase in yield of rice by 10-20% and save on inorganic nitrogen fertilizer equivalent to 25-30 kg N ha⁻¹ season⁻¹ (Venkataraman, 1979; Kaushik, 1994). The vesicular arbuscular mycorrhizae (VAM) are of special significance as they improve nutrient uptake and thereby contribute to improved productivity. Improved yields have been obtained in a number of vegetables - potato, brinjal, onion, chillies and cereals - wheat, maize, pearl millet and sorghum (Bagyaraj, 1984).

Large number of inoculation trials with microbial inoculants have been done in isolation either with nitrogen fixing or phosphate solubilising organisms. However, studies on the use of multiple inoculants in rice-wheat cropping

system are scanty. Some recent research findings have brought to light instances where biological activities are markedly enhanced in two or three members associations of organisms (Singh and Singh, 1993). The present study, therefore, aims at employing a consortium of organisms as biofertilizers for rice and wheat crop, which includes BGA, phosphate solubilising bacterium (PSB) and vesicular-arbuscular mycorrhizal fungus (VAMF).

MATERIALS AND METHODS

The experiments were done at IARI fields with a plot size of 10 sq. M (4M×2.5M) in RBD/design in 1999-2000 and 2000-2001. The crop varieties were HD-2329 for wheat and Pusa-44 for rice for both the cropping seasons. The fertilizer doses as N : P : K were 120 : 60 : 60. Potash as muriate of potash was applied as basal whereas nitrogen as three and two split doses in rice and wheat, respectively. P was given either 100% as single super phosphate (SSP) or fifty-fifty both by SSP and Udaipur rock phosphate (URP) in the beginning. Bacterial biofertilizer phosphate solubilising bacteria (PSB) were given as seedling treatment for rice and seed application for wheat crop. Vesicular arbuscular mycorrhiza (VAM) was given as soil application. BGA in rice was applied after

seeding transplantation and in wheat with first irrigation after seed germination. Individual components of microbial inoculants were *Anabaena variables*, *Nostoc muscorum*, *Aulosira fertilissima* and *Tolypotrrix tenuis* for BGA, *Pseudomonas striata* for PSB and *Glomus mossae* for VAM fungi.

After the harvest of each crop soil samples were collected and analyzed for total N by Kjeldahl method (Jackson, 1973), available P (Olsen, 1954), and organic carbon by chromic oxidation method (Walkley and Black, 1934). The total microbial activity was assessed through measuring the soil dehydrogenase activity. This method involves calorimetric determination of 2, 3, 5-triphenyl formazon (TPF) produced by the reduction of 2, 3, 5-triphenyl tetrazolium chloride (TTC) by soil microorganisms (Casida *et al.*, 1964).

RESULTS AND DISCUSSION

Yield response

Results given in Table 1 are based on rice and wheat (2001 and 2002). Although the paddy yield differed in the both cropping seasons but taking in to account average of two years, the

grain yield in control (120 kg N) was 40.6 q ha⁻¹. Application of phosphatic fertilizer as SSP both at the level of 30 and 60 kg ha⁻¹ increased the yield of paddy to 43.96 and 47.65 q ha⁻¹ respectively. Substituting the SSP, with URP at 30 and 60 kg phosphorus per hectare resulted to a yield equivalent of 43.75 and 47.56 q ha⁻¹ respectively which was equivalent to the supply of P as SSP. Application of P as 50% through SSP and remaining 50% as URP no doubt increased the yield over the application of 30 kg P either through SSP or URP but was not at par with application of 60 kg of P as SSP or URP. The yield obtained in control, 30 kg P as SSP and 30 kg P as URP were statistically at par. Application of bioinoculants alone (BGA, PSB or VAM) in presence of 50% SSP plus 50% URP as a source of P were at par with P 100% SSP. The significant enhancement of paddy yield was observed only when BGA plus PSB or BGA plus PSB plus VAM were employed.

The wheat yield in control as well as due to application of URP both at 30 or 60 kg phosphorus were statistically at par, suggesting that application of URP alone without any bioinoculants does not enhance crop yield. Application of individual bioinoculants either

Table 1. Influence of biofertilizer application on paddy and wheat

Treatments (kg/ha)	Average paddy yield (q/ha ⁻¹)		Average wheat yield (q ha ⁻¹)	
	Grain	Straw	Grain	Straw
T-1: Control (N:K, 120:60)	40.62	74.09	45.16	49.23
T-2: T-1 + P60 AS SSP	47.65	81.53	51.29	56.40
T-3: T-1 + P30 AS SSP	43.96	80.91	50.17	52.43
T-4: T-1 + P60 AS URP	47.56	81.93	45.84	51.27
T-5: T-1 + P30 AS URP	43.75	80.04	45.05	56.92
T-6: T-1 + P30 AS SSP+P30 as URP	46.28	84.86	47.28	51.76
T-7: T-6 + PSB	47.30	80.61	49.89	56.17
T-8: T-6 + VAM	47.74	86.49	49.57	53.98
T-9: T-6 + BGA	47.69	81.47	47.74	53.17
T-10: T-6 + PSB + VAM	47.83	80.45	52.05	56.91
T-11: T-6 + PSB + BGA	49.76	92.30	48.56	55.82
T-12: T-6 + VAM + BGA	45.09	81.00	51.24	53.79
T-13: T-6 + PSB + VAM + BGA	49.56	81.85	53.60	61.97
T-14: T-3 + PSB + VAM + BGA	49.39	87.24	52.92	58.50
T-15: T-5 + PSB + VAM + BGA	46.26	87.08	50.99	56.06
C.D. at 5%	3.00	NS	3.32	NS

PSB, VAM or BGA although produced higher yield than control but the yields were not equivalent to 60 kg phosphorus as SSP. Application of PSB and VAM, PSB plus VAM and BGA in presence of 50% P as SSP plus 50% P as URP gave higher yield, but were statistically at par with 100% P as SSP. The bioinoculants (BGA+VAM+PSB) produced an additional 2.31 q ha⁻¹ wheat grain over 60 kg P₂O₅ as SSP.

The response of straw was significant to the application of bioinoculants both in wheat and rice in the year 2001 and 2002. However, the average of two year data were non-significant. These results clearly brought out the fact that substitution of 50% of P₂O₅ through URP alone with biofertilizers resulted in a net saving of 30 kg P₂O₅ or 188 kg SSP ha⁻¹ with an additional yield of paddy and wheat. On an average a 4.0 quintals of additional grain yield including paddy and wheat can be obtained by using the three bioinoculants i.e. VAM, PSB and BGA.

The positive benefits from inoculation have been attributed to several mechanisms such as nitrogen fixation, phytohormone production, and enhanced uptake of nutrient (Wani, 1997) and phosphate solubilization (Gaur, 1990). Therefore, in the present investigation the beneficial effects observed in various treatments especially where PSB and/or VAM are present along with BGA can be related to similar mechanisms. A similar pattern of observations has been reported by many workers based on the interaction studies between nitrogen fixing microorganisms (Baltensperger et al. 1978; Dhillon 1992). Poi et al. (1989) observed that the PSM interacts positively with the VAM in the P deficient soils or soil amended with rock phosphate.

Grain quality

The quality of rice and wheat grain in terms of nitrogen and phosphorus content was analyzed. Grain percentage of nitrogen of rice was significantly higher over the application of nitrogen alone or nitrogen with SSP or URP. In general the percentage of rice grain nitrogen varied from 1.20 to 1.30 due to inorganic inputs, whereas, it was enhanced to as low as 1.28 due to VAM inoculation to as high as 1.47 with the inoculation of BGA alone with VAM and PSB. This nitrogen content was significantly higher

than over uninoculated controls containing full dose of N and P as inorganic inputs. The grain phosphorus content of rice was significantly higher only in the treatment, which received PSB alone or in combination with VAM. P content in grains due to BGA alone inoculation was at par with control. Use of BGA along with PSB and VAM led to rice grain P content at par with 60 kg P₂O₅ as SSP (Table 2).

The nitrogen % of wheat in control (100% N-fertilizer) was at par with the treatment received phosphatic fertilizer either at 30 or 60 kg ha⁻¹ both with SSP or URP. The microbial inoculants significantly improved the % grain nitrogen content in wheat. Inoculation with BGA alone or along with PSB and VAM led to a significant increase in wheat grains over control as well as 60 kg P₂O₅ as SSP or URP and the best 1.64% wheat grain N was recorded due to combined application of PSB, VAM and BGA. Similar to nitrogen content of wheat, inoculation with different bioinoculants also led to increased phosphorus content of grains over control but significantly higher grain phosphorus content was observed when inoculated with PSB or VAM. The dual inoculation with PSB and BGA or VAM improved further significantly the P content of wheat grains over 100% P as SSP. The remaining treatments with phosphatic fertilizer or rock phosphate were statistically at par (Table 2).

Quality of straw

The wheat straw in north and rice straw in south India is commonly fed to the cattle, therefore the quality of straw in terms of nitrogen and phosphorus was also assessed. There was significant improvement in the straw nitrogen and phosphorus content of rice and wheat due to binoculants (Table 3). The percentage of nitrogen in control (100% N) or phosphorus (50 or 100%) either as SSP or URP showed the rice straw nitrogen content from 0.39-0.46. Inoculation with BGA alone or in combination with VAM or PSB plus VAM showed significantly higher nitrogen content of rice straw (0.47-0.48%) over control as well as single inoculation with PSB or VAM. Wheat straw was highly enriched in terms of percentage nitrogen content, whenever, bioinoculants were used alone or in

Table 2. Influence of biofertilizer application on grain N and P content of paddy and wheat

Treatments (kg/ha)	Quality of rice		Quality of wheat	
	N%	P%	N%	P%
T-1 : Control (N:K, 120:60)	1.20	0.22	1.51	0.47
T-2 : T-1 + P60 AS SSP	1.22	0.26	1.53	0.55
T-3 : T-1 + P30 AS SSP	1.22	0.24	1.52	0.53
T-4 : T-1 + P60 AS URP	1.27	0.27	1.54	0.53
T-5 : T-1 + P30 AS URP	1.23	0.23	1.53	0.49
T-6 : T-1 + P30 AS SSP+P30 as URP	1.30	0.25	1.55	0.53
T-7 : T-6 + PSB	1.35	0.29	1.56	0.58
T-8 : T-6 + VAM	1.28	0.27	1.58	0.58
T-9 : T-6 + BGA	1.40	0.22	1.59	0.55
T-10 : T-6 + PSB + VAM	1.35	0.28	1.61	0.59
T-11 : T-6 + PSB + BGA	1.37	0.26	1.58	0.61
T-12 : T-6 + VAM + BGA	1.46	0.25	1.62	0.58
T-13 : T-6 + PSB + VAM + BGA	1.47	0.26	1.64	0.63
T-14 : T-3 + PSB + VAM + BGA	1.37	0.27	1.62	0.58
T-15 : T-5 + PSB + VAM + BGA	1.37	0.27	1.65	0.57
C.D. at 5%	0.10	0.027	0.037	0.028

Table 3. Influence of biofertilizer application on the quality of straw as N and P of paddy and wheat

Treatments (kg/ha)	Quality of paddy straw		Quality of wheat straw	
	N%	P%	N%	P%
T-1 : Control (N:K, 120:60)	0.39	0.12	0.23	0.022
T-2 : T-1 + P60 AS SSP	0.41	0.14	0.26	0.030
T-3 : T-1 + P30 AS SSP	0.43	0.14	0.25	0.027
T-4 : T-1 + P60 AS URP	0.44	0.12	0.27	0.031
T-5 : T-1 + P30 AS URP	0.41	0.12	0.24	0.027
T-6 : T-1 + P30 AS SSP+P30 as URP	0.46	0.15	0.28	0.034
T-7 : T-6 + PSB	0.43	0.16	0.36	0.038
T-8 : T-6 + VAM	0.41	0.14	0.33	0.037
T-9 : T-6 + BGA	0.47	0.15	0.32	0.035
T-10 : T-6 + PSB + VAM	0.43	0.17	0.36	0.042
T-11 : T-6 + PSB + BGA	0.45	0.16	0.35	0.036
T-12 : T-6 + VAM + BGA	0.48	0.13	0.34	0.040
T-13 : T-6 + PSB + VAM + BGA	0.47	0.16	0.38	0.045
T-14 : T-3 + PSB + VAM + BGA	0.44	0.17	0.37	0.039
T-15 : T-5 + PSB + VAM + BGA	0.42	0.17	0.34	0.033
C.D. at 5%	0.04	0.027	0.040	0.006

combination. The best nitrogen content in wheat straw was recorded to be 0.33-0.38 when BGA was inoculated with VAM and PSB.

Similar to nitrogen, the phosphorus content of rice straw was significantly different in the treatment where either PSB alone or with VAM

and BGA were used as bioinoculants (Table 3). In rest of the treatments the P content of rice straw was higher than the straw in uninoculated control. The application of phosphorus at 60 kg P_2O_5 ha⁻¹ in wheat resulted significantly higher P content in wheat straw over control as well as

over 30 kg P_2O_5 as SSP or URP. The application of PSB or VAM either alone or in combination with or without BGA significantly enhanced the straw phosphorus content of wheat (Table 3). Tanni and El-Fattah (1999) recorded increase in N content of paddy due to coinoculation of BGA, *Azospirillum* and *Azotobacter* along with 1/3 of chemical N recommended ha^{-1} . Increased N fixation and production of growth substances, most probably by BGA can be attributed for this differential effect as has been reported earlier (Tien *et al.* 1979). The increase in P content in paddy and wheat grains may be due to solubilization of applied rock phosphate by PSB and subsequent increase in mobilization by VAMF. Dhillon (1992) also observed increase in nutrient acquisition by paddy due to interaction between a *Pseudomonas* spp. and VAM. These results have clearly brought out the fact that bio-inoculants significantly improved the quality of grain as well as straw of both rice and wheat. The quality of wheat in particular was better enhanced than rice.

Influence of microbial inoculation on soil properties

After the harvest of each crop paddy and wheat, the soils were analyzed for pH, electrical conductivity, organic carbon, total nitrogen and available phosphorus. There were no perceptible changes in soil pH due to any of the treatment during paddy and wheat crop and pH varied only between 8.1-8.2. Similarly no major change in electrical conductivity of the soil after harvest of the rice and wheat crop was observed (data not included).

The percentage soil organic carbon in control (100% N) after the harvest of paddy was significantly less than the treatment received both nitrogen and phosphorus (50 or 100%) either with SSP or URP. Inoculation with either of the inoculants though significantly improved soil organic carbon % over control but were almost at par with P_2O_5 (50 or 100%) except the inoculant PSB. The organic carbon content after the harvest of paddy crop due to BGA varied between 0.69-0.73%. In contrast to the results obtained in organic carbon % during paddy crop, wheat crop responded differently. Inoculation with BGA alone or with PSB or VAM significantly improved the soil organic carbon content over the all other

treatments (Table 4). There was enhanced organic carbon content in soil even without bioinoculants. Such enhancement may be due to stimulation of indigenous heterotrophic/phototrophic microorganisms due to either enhanced nutrient availability through inorganic fertilizers or through plant root exudates.

The soil nitrogen build-up during the paddy cultivation did not differ significantly except in treatments with BGA inoculants along with PSB and VAM. However, inoculation with either PSB or VAM individually though increased the soil nitrogen content but at par with control. The soil nitrogen status after the harvest of wheat crop was significantly higher with microbial inoculants as well as with phosphatic fertilizers over control. The maximum enhancement in soil nitrogen was observed when BGA was applied along with either of PSB and VAM. On examining the average nitrogen status after the two years rice-wheat crops in all the treatments wherever phosphatic fertilizer was applied, significantly higher nitrogen content was observed over the control (120 kg nitrogen). The application of phosphatic solubilizers/mobilizers or nitrogen fixing biofertilizer used, showed significantly higher soil nitrogen (Table 4).

In general the soil phosphorus content was low after the harvest of rice crop as compared to the harvest of wheat crop. All the treatments with the application of SSP or URP showed higher P content than the control. There was no significant enhancement in the available P content after the harvest of paddy due to bioinoculants and statistically it was at par with 60 kg P_2O_5 as SSP. On the contrary a significant enhancement in available P content (21.73-28.28 kg ha^{-1}) was seen with different bioinoculants over control (17.32 kg ha^{-1}). Similarly BGA with PSB or BGA with PSB and VAM inoculation led to a significantly higher available P (24.75-28.28 kg ha^{-1}) over the application of 60 kg ha^{-1} SSP (21.28 kg ha^{-1}). This suggests that due to the use of phosphatic fertilizer plus rock phosphate with microbial inoculant led to the enhanced available phosphorus at the time of harvest of the wheat crop (Table 4). This enhanced available P content after the harvest of wheat crop as compared to rice may be because of more aerobic environment

during Rabi season as compared to kharif where puddling is traditionally being done before transplanting the paddy seedlings (Table 4).

Maintenance of soil fertility is vital for sustained crop production. Microorganisms play a leading role in improving soil fertility. Beneficial effect of microbial inoculants on soil fertility is well documented (Kaushik, 1985; Rogers *et al.* 1991). In the present investigation biofertilizer application resulted in considerable improvement in the fertility status of soil, by increasing the N, P and organic carbon content. The beneficial effect was much more pronounced after the harvest of wheat crop in case of soil N, organic carbon and available P. This can be attributed to the greater aerobic conditions of soil during wheat cultivation rather than during the paddy crop. Rice fields present unique conditions for the activity of a number of microorganisms. Although the bulk of the surrounding soil is predominantly anaerobic because of submergence, the rice rhizosphere remains aerobic to microaerobic mainly due to downward transport of air through rice plants (Toshida and Broadbent, 1975). The results on improved yield and quality of grains as well as enrichment of soil were further substantiated

with increased activity of microorganisms measured as soil dehydrogenase activity (Table 5). The soil dehydrogenase activity was relatively greater after the harvest of wheat rather than rice crop. The microbial inoculants had increased dehydrogenase activity over the inorganic inputs nitrogen and phosphorus.

The increase carbon content may be more due to photosynthetic BGA and greater availability of P due to the activities of PSB and VAM. The beneficial effects of inoculating crop plants with VAM are well known (Jeffries, 1987); rice in the tropics has received little attention in mycorrhiza research. Recent studies have shown that plant growth, P nutrition and Zn nutrition of wetland rice were improved under pot culture conditions (Sharma *et al.* 1988; Dhillon 1992).

A number of unanswered questions still exist on the interaction of inoculated microorganism in rhizosphere though the positive influence of inoculated microbes on native microorganisms has been demonstrated (Lynch 1983). This investigation clearly brings to light the synergistic effects of PSB, BGA and VAM. On the basis of our observations the combination 30 SSP + 30 URP + PSB + VAM + BGA can be effective combination for deriving maximum

Table 4. Influence of biofertilizer application on organic carbon, total nitrogen and available phosphorus content of soil after the harvest of rice and wheat

Treatments (kg/ha)	After paddy harvest 2000-01			After wheat harvest 2001-02		
	Org. C%	N kg ha ⁻¹	Avail. P kg ha ⁻¹	Org. C%	N kg ha ⁻¹	Avail. P kg ha ⁻¹
T-1 : Control (N:K, 120:60)	0.65	283.35	7.53	0.60	285.75	17.32
T-2 : T-1 + P60 AS SSP	0.73	343.34	10.01	0.67	314.19	21.28
T-3 : T-1 + P30 AS SSP	0.73	313.03	9.41	0.65	304.42	21.26
T-4 : T-1 + P60 AS URP	0.73	303.80	9.99	0.69	344.84	19.18
T-5 : T-1 + P30 AS URP	0.74	341.62	9.35	0.67	331.00	19.34
T-6 : T-1 + P30 AS SSP+P30 as URP	0.71	334.92	9.66	0.71	325.41	19.20
T-7 : T-6 + PSB	0.71	351.63	10.11	0.71	354.64	23.65
T-8 : T-6 + VAM	0.75	314.37	9.20	0.74	368.52	23.29
T-9 : T-6 + BGA	0.71	304.09	9.28	0.75	310.89	23.33
T-10 : T-6 + PSB + VAM	0.72	287.16	10.07	0.70	319.27	23.89
T-11 : T-6 + PSB + BGA	0.69	365.33	10.36	0.73	372.96	24.75
T-12 : T-6 + VAM + BGA	0.72	375.418	9.67	0.75	375.80	21.73
T-13 : T-6 + PSB + VAM + BGA	0.70	363.10	10.42	0.72	365.47	28.28
T-14 : T-3 + PSB + VAM + BGA	0.71	374.98	9.57	0.73	387.80	25.38
T-15 : T-5 + PSB + VAM + BGA	0.73	349.62	9.82	0.70	340.22	21.05
C.D. at 5%	0.04	36.78	0.96	0.027	13.82	1.88

Table 5. Influence of biofertilizer application on soil dehydrogenase activity after the harvest of paddy and wheat

Treatments (kg/ha)	mg TPF g ⁻¹ soil h ⁻¹	mg TPF g ⁻¹ soil h ⁻¹
T-1 : Control (N:K, 120:60)	14.55	26.31
T-2 : T-1 + P60 AS SSP	20.70	36.40
T-3 : T-1 + P30 AS SSP	21.57	32.95
T-4 : T-1 + P60 AS URP	25.27	33.45
T-5 : T-1 + P30 AS URP	21.14	31.40
T-6 : T-1 + P30 AS SSP+P30 as URP	22.88	35.97
T-7 : T-6 + PSB	25.53	41.19
T-8 : T-6 + VAM	24.49	33.70
T-9 : T-6 + BGA	25.10	42.18
T-10 : T-6 + PSB + VAM	25.44	40.80
T-11 : T-6 + PSB + BGA	23.23	44.55
T-12 : T-6 + VAM + BGA	23.62	46.28
T-13 : T-6 + PSB + VAM + BGA	24.18	50.65
T-14 : T-3 + PSB + VAM + BGA	24.23	43.84
T-15 : T-5 + PSB + VAM + BGA	24.66	41.67
C.D. at 5%	4.57	5.04

benefits. Inclusion of VAM in rice cultivation has been shown probably for the first time as P scavenging/mobilizing agent. In the future, it can be hypothesized that one would be able to replace up to 50% of the chemical phosphatic fertilizers with a consortia of organisms efficient in nutrient scavenging, mobilization and transport to crop, thereby aiding in effective

integrated nutrient management strategies in agriculture.

ACKNOWLEDGMENTS

The authors are thankful to the Department of Biotechnology, GOI, to provide financial support to carry out this investigation.

REFERENCES

- Bagyaraj, D.J. 1984. Biological interactions with VA mycorrhizal fungi. (In) VA mycorrhizae. C.L. Powell, D.J. Bagyaraj, Editors, CRC Press Inc. Boca Raton, Florida, USA, p. 234.
- Baltensperger, A.A., Schank, S.C., Smith, R.L., Lither, R.C., Bouton, J.H. and Dudeck, A.E. 1978. Effect of inoculation with *Azospirillum* and *Azotobacter* on turf type Bermuda genotypes. *Crop Science*, 18 : 1043-45.
- Casida, L.E., Klein, Jr. D.A. and Sautoro, T. 1964. Soil dehydrogenase activity. *Soil Science*, 98 : 371-76.
- Dhillon, S.S. 1992. Dual inoculations of pre-transplant stage *Oryza sativa* L. Plants with indigenous vesicular arbuscular mycorrhizal fungi and fluorescent *Pseudomonas* spp. *Biology and Fertility of Soils*, 13 : 147-51.
- Gaur, A.C. 1990. Phosphate solubilizing microorganisms as biofertilizers. Omega Scientific Publishers, New Delhi, p. 176.
- Kaushik, B.D. 1985. Effect of native algal flora on nutritional and physio-chemical properties of sodic soils. *Acta Botanica Indica*, 13 : 143-47.
- Kaushi, B.D. 1994. Blue green algae and sustainable agriculture. (In) Natural Resource Management for sustainable Agriculture and Environment. D.L. Deb., Editor, Angkor Publishers, New Delhi, pp. 404-416.
- Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, p. 498.
- Lynch, J.M. 1983. Microbiological factors in crop productivity. (In) Sol Biotechnology Blackwell Scientific Publications, Oxford.
- Olsen, S.R. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939.
- Rogers, S.L., Cook, K.a. and Burns, R.G. 1991. Microalgal and cyanobacterial soil inoculants and their effect on soil aggregate stability. (In)

- Advances in soil organic matter research; the impact on agriculture and the environment, W.S. Wilson, Editor, Royal Society of Chemistry, Cambridge, pp. 175-184.
- Singh, H.P. and Singh, T.A. 1993. The interaction of rock phosphate, Bradyrhizobium, vesicular arbuscular mycorrhizal and phosphate solubilizing microbes on soybean growth in a sub-Himalayan mollisol. *Mycorrhiza*, 4 : 37-43.
- Sharma, A.K., Singh, R. and Singh, V.A. 1988. Effect of vesicular-arbuscular mycorrhiza on uptake of phosphorus and zinc in rice (*Oryza sativa* L.). *Current Science*, 57 : 901-02.
- Tien, T.M., Gaskins, M.H. and Hubbell, D.H. 1979. Plant growth substances produced by *Azospirillum brasilense* and their effect on the growth of pearl millet (*Pennisetum americanum* L.). *Applied and Environmental Microbiology*, 37 : 1016-24.
- Venkataraman, G.S. 1979. Algal inoculation of rice fields. (In) Nitrogen and Rice. International Rice Research Institute, Los Banos, Philippines, pp. 321-31.
- Walkley, A.J. and Black, I.A. 1934. Estimation of soil organic carbon by the chromic acid titration method. *Soil Science*, 37 : 29-38.
- Wani, S.P. 1997. Role of free living and associative diazotrophs in non-legumes under sustainable conditions. (In) Biotechnological approaches in soil microorganisms for sustainable crop production. K.R. Dadarwal. Editor, Scientific Publishers, Jodhpur, India, pp. 109-127.
- Yanni, Y.g. and El-Fattah, F.K.A. 1999. Towards integrated biofertilization management with free living and associative dinitrogen fixers for enhancing rice performance in the Nile delta. *Symbiosis rehovot*, 27 : 319-31.
- Yoshida, T. and Broadbent, F.E. 1975. Movement of atmospheric nitrogen in rice plants. *Soil Science*, 120 : 288-91.

GENETIC DIVERSITY IN PERFORMANCE PER SE AND ECONOMIC HETEROSIS AMONG NEWLY DEVELOPED A₁ CYTOPLASMIC MALE STERILE LINES AND RESTORERS IN PEARL MILLET

K.V. UNNIKRISHNAN, BALZOR SINGH, RAMESH SINGH, A.P.S. VERMA AND K.P. SINGH

*Division of Genetics
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

A study was undertaken with a view to assess the diversity among newly developed downy mildew resistant A₁ cytoplasmic male sterile lines (CMS) and restorers in terms of their performance per se in hybrid combination for a range of agronomic traits in pearl millet. The results of range of mean, genotypic variance for yield and yield attributing characters indicated the presence of sufficient genetic diversity among CMS lines and restorers. Sixteen hybrids exhibited significantly positive economic heterosis for grain yield per plant and also for other components of yield. From this study, it is apparent that there is sufficient variability present among newly developed restorers and CMS lines to produce a range of genetically diverse hybrids with high grain yield.

Key words : New male sterile lines, economic heterosis, pearl millet.

Pearl millet is cultivated on about 20 million hectare in the world and it ranks sixth among cereals. It is grown in Africa, India and other Asian countries as the principal grain crop but also popular as forage crops. In India, it occupies fourth position among cereal crops, next to rice, wheat and sorghum. Pearl millet is grown on 9.62 million hectare in arid and semi arid regions of India, which is nearly 40% of the world area for this cereal. While the area is one the decline, but the total production and productivity of pearl millet in India are on the increase, mainly attributed to cultivation of improved cultivars. All pearl millet hybrids cultivated in India are based on A₁ cytoplasmic genetic male sterility. When devastating epidemics of downy mildew caused by *Sclerospora graminicola* (sacc.) nearly wiped out the crop in the 1970's following the introduction of hybrids, A₁ cytoplasm was linked with the susceptibility to this disease [Safeulla, 1970]. However, studies shown by Anand Kumar *et al.* [1983], Yadav *et al.* [1993], and Dave [1987] suggested that the main reasons for downy mildew out break was due to the lack of genetic diversity among cytoplasmic male sterile (CMS) lines and elite restorers rather than any deleterious effects on the A₁ cytoplasm itself.

Therefore, the present study was undertaken with a view to assess the diversity among newly developed downy mildew resistant CMS lines and restorers bred at IARI by the authors, in terms of their performance per se in hybrid combination for a range of agronomic traits.

MATERIALS AND METHODS

Four newly developed CMS lines namely MS 576 A, MS411 A, MS273 A and MS 379 A along with two checks MS 841 A and MS 5054 A were used as female parents. The six male sterile lines were crossed to 34 inbred lines in a line $\times$ tester design during kharif 2000 to generate 204 hybrid combinations. These 204 hybrids with 40 parents were planted in a randomized block design with three replications during kharif 2001 at IARI, New Delhi. The parents and F₁'s were randomized among them and sown in adjoining blocks. All the hybrids and parents were evaluated in a 3 m long single row plot with spacing of 45 cm $\times$ 15 cm between the rows and plants, respectively. Data were recorded on ten randomly selected plants from each plot on days to 50% flowering, plant height, number of effective tillers/plants, ear length, ear girth, 1000 grain weight and grain yield per plant. The

analysis of variance was carried out separately for each character, and economic heterosis was determined relatively to a commercial hybrid control Pusa 605 (MS 841A $\times$ PPMI 69) by the procedure suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The genotypic variance and the ranges for mean for each character studied (Table 1) clearly revealed the presence of genetic diversity among the newly developed male sterile lines and restorer lines in terms of their performance per se. Among CMS lines, days to 50% flowering ranged from 45 days (MS 379A) to 50 days (MS 5054A). The CMS lines selected for the present study did not show much variability for this character because at IARI, in male sterile lines development programme, the major thrust is to provide early maturing male sterile lines. This enables to develop early maturing hybrids suitable for growing in moisture stress areas. Among the restorer lines the range was 43 days (PPMI 767) to 55 days (PPMI 295) and the genotypic variance of 6.61 indicating sufficient variability is available for this traits. The plant height of the CMS lines ranged from 87 cm (MS 273A) to 162 cm (MS 841A) and restorer lines from 88 cm (PPMI 605) to 200 cm (D 23). The genotypic variance for this character is very high for both CMS and restorer lines indicating the presence of adequate variability for this trait. Similarly, the ranges and genotypic variance for effective tiller number, ear length, ear girth and 1000 grain weight among the CMS lines and restorers indicated the presence of adequate variability for these traits among the parental lines. In case of grain yield per plant, that integrates these grain yield components, the range 11.53 to 60.43 and genotypic variance (214) was greater among restorers than for CMS lines (Range 17.23 to 46.53; genotypic variance 143).

The performance of hybrids in relation to both per se and the economic heterosis of the best hybrid check Pusa 605 (MS 841A $\times$ PPMI 69) also indicated the presence of sufficient genetic diversity among CMS lines and restorers for all the yield attributing traits (Table 1). The grain

yield per plant of the hybrids ranged from 25.53g; economic heterosis of -64.1% (MS 5054A $\times$ PPMI 738) to 126.7 g; economic heterosis of 78.4% (MS 576A $\times$ D23) and the genotypic variance for the grain yield was high (410). Sixteen hybrids out of 204 hybrids exhibited significantly positive economic heterosis for this character (Table 2). Observations on yield attributing components of individual plant yield were similar. These results were also substantiates the findings of Govila *et al.* (1997).

Among the hybrid tested MS 379A $\times$ PPMI 190 was the earliest to flower (42 days). At Indian Agricultural Research Institute, New Delhi, the main emphasis is given to breed early maturing hybrids suited for moisture stress areas of the pearl millet growing regions of India. Therefore, this early maturing hybrid (MS 379A $\times$ PPMI 190), which has out yielded the best check Pusa 605 by + 7.25%, would be ideally suited for these areas. The genotypic variance among hybrids for days to 50% flowering was less than the parental lines despite the range observed for hybrids being slightly larger. This is perhaps due to the dominance of, and heterosis for, early flowering among the parental lines studied. The similar situation was observed for plant height due to dominance of, and heterosis for, tallness. From this study, it is apparent that there is sufficient variability present among newly developed restorers and A_1 cytoplasmic male sterile lines to produce a range of genetically diverse hybrids with high grain yield. As the A_1 sources of cytoplasmic male sterility system is the most stable of those first reported by Burton and Athwal (1967), and can have a positive influence on general combining ability for various characters as reported by Prakash *et al.* (1987). Therefore, genetically diverse male sterile lines in A_1 background, resistant to down mildew disease may be continued to use in pearl millet hybrid breeding programme as it should not cause any difficulty. However, exploitation of other sources of cytoplasm for further diversification of CMS base of pearl millet hybrids may be pursued as suggested by Henna (1989).

Table 1. Variability in performance per se and economic heterosis relative to Pusa 605 (MS 841A × PPMI 69) for a range of yield attributing traits among 40 pearl millet parental lines and their hybrids

Character	Cytoplasmic male sterile lines per se			Restorer lines per se			Hybrids per se and economic heterosis		
	Minimum	Maximum	Genotypic variance	Minimum	Maximum	Genotypic variance	Minimum	Maximum	Genotypic variance
Days to 50% flowering	45 (379 A) ¹	50 ³ (5054 A)	1.85	43 (PPMI 767)	55 ³ (PPMI 295)	6.61	42[-10.6] ² (MS379A × PPMI 190)	58[23.4] (MS 5054 A × PPMI 295)	4.65
Plant height (cm)	87 (273 A)	162 ³ (841 A)	983	88 (PPMI 605)	200 ³ (D 23)	724	127 [-31.0] (MS 379 A × PPMI 295)	228 [24.0] (MS 411 A × PPMI 814)	192
Effective tillers/plant	2.0 (411 A)	4.3 ³ (5054 A)	0.54	2.0 (PPMI 605)	8.7 ³ (PPMI 362)	1.70	2.2 [-26.7] (MS 576 A × PPMI 190)	4.1 [36.7] (MS 5054 A × PPMI 872)	0.14
Ear length (cm)	16.63 (5054 A)	20.80 ³ (841 A)	2.81	9.85 (PPMI 739)	28.00 ³ (PPMI 493)	19.24	18.27 [-31.6] (MS 273 A × PPMI 479)	31.00 [16.1] (MS 841 A × PPMI 809)	5.72
Ear girth (cm)	1.41 (5054 A)	2.69 ³ (411 A)	0.19	1.32 (PPMI 812)	3.06 ³ (PPMI 605)	0.16	1.61 [-31.5] (MS 5054 A × PPMI 856)	3.60 [53.2] (MS 576 A × PPMI 295)	0.18
1000 grain weight (g)	4.27 (5054 A)	11.93 ³ (411 A)	6.20	4.06 (PPMI 739)	13.09 ³ (PPMI 814)	3.58	6.85 [-30.4] (MS 841 A × PPMI 85)	13.69 [39.1] (MS 411 A × PPMI 295)	2.24
Grain yield/plant (g)	17.23 (273A)	46.53 ³ (411A)	143	11.53 (PPMI 739)	60.43 ³ (PPMI 295)	214	25.53 [-64.1] (MS 5054 A × PPMI 738)	126.70 [78.4] (MS 576 A × D 23)	410

1. Parents and hybrids exhibiting minimum and maximum values for each character are indicated in parentheses.

2. Economic heterosis value (%) of hybrids relative to Pusa 605 (MS 841A × PPMI 69) are indicated in square brackets.

3. Differences between minimum and maximum values are significant

Table 2. The yield attributing characters of 16 hybrids (and their parental lines) having grain yields significantly superior to control hybrid Pusa 605 (MS 841 A × PPMI 69)

Hybrid/male sterile/restorer	Days to 50% flowering	Plant height (cm)	Effective tillers/plant	Ear length (cm)	Ear girth (cm)	1000 grain weight (g)	Grain yield/plant (g)	Percent superiority of hybrids over check for grain yield
Hybrids								
MS 576 A × D 23	47.3	203	2.80	26.80	2.92	8.84	126.80**	38.9
MS 576 A × PPMI 295	54.7	206	2.60	25.10	3.60	10.65	123.30**	35.0
MS 576 A × PPMI 807	49.0	206	3.10	27.60	2.74	10.72	122.40**	34.1
MS 411 A × PPMI 301	46.0	201	2.80	24.40	3.07	10.39	121.90**	33.5
MS 841 A × PPMI 295	48.0	198	2.90	28.00	2.77	9.54	119.50**	30.9
MS 411 A × PPMI 162	49.3	210	2.90	24.50	2.79	12.21	118.70**	30.0
MS 411 A × PPMI 85	50.7	207	3.20	25.10	2.98	10.45	115.10**	26.1
MS 273 A × PPMI 814	50.7	213	3.10	25.40	3.08	9.77	109.50**	19.9
MS 576 A × PPMI 575	48.7	209	2.60	25.30	3.08	10.03	107.20**	17.4
MS 576 A × PPMI 493	49.3	209	2.90	25.40	3.36	10.25	107.00**	17.2
MS 379 A × PPMI 641	49.3	198	3.50	26.80	2.60	12.16	103.20**	13.8
MS 576 A × PPMI 814	50.7	214	3.20	25.50	3.36	10.31	102.80**	12.6
MS 273 A × PPMI 493	47.7	206	2.90	28.20	2.86	11.78	101.90**	11.6
MS 411 A × PPMI 809	48.0	213	3.00	28.60	2.95	11.16	99.90**	9.4
MS 411 A × PPMI 641	47.7	204	2.90	25.00	2.92	10.68	98.80*	8.2
MS 379 A × PPMI 190	42.3	200	2.80	23.40	2.48	11.22	97.92*	7.3
PUSA 605 (check)	47.0	184	3.00	26.70	2.35	8.04	91.30	
Male Sterile Lines								
MS 576 A	49.7	150	3.33	19.90	2.39	8.19	36.60	
MS 411 A	47.7	112	2.00	17.47	2.93	11.93	46.53	
MS 841 A	49.0	162	3.33	20.80	1.97	9.49	41.53	
MS 273 A	46.7	87	3.33	16.97	2.29	7.90	27.17	
MS 379 A	46.0	93	3.33	18.60	2.29	8.30	41.50	
Restorer Lines								
D 23	52.0	200	2.90	26.80	2.63	10.12	47.30	
PPMI 295	54.1	100	4.30	25.20	2.98	7.68	16.60	
PPMI 807	47.0	163	3.30	26.30	1.85	10.18	26.30	
PPMI 301	46.1	170	2.90	20.30	2.69	9.82	41.40	
PPMI 162	47.0	155	2.30	15.80	2.04	5.08	16.30	

contd...

Table 2 contd...

PPMI 85	47.1	132	3.80	18.30	2.15	5.16	31.60
PPMI 814	50.0	164	2.70	26.80	2.94	13.04	51.50
PPMI 575	48.1	107	2.90	21.80	2.56	10.11	20.70
PPMI 493	48.2	152	3.10	27.20	2.70	10.07	26.50
PPMI 641	48.0	137	2.70	18.20	2.48	9.81	26.80
PPMI 809	47.2	175	3.10	22.80	2.55	6.52	30.50
PPMI 190	46.0	165	2.60	25.50	2.64	11.38	56.30
PPMI 69	46.2	135	2.90	22.40	2.25	6.44	22.40
Trial hybrid mean	47.6	200	3.00	25.31	2.54	9.84	71.02
Male sterile mean	47.1	124	3.30	18.39	2.17	8.35	34.14
Restorer mean	47.8	151	3.50	19.36	2.10	7.29	28.68
C.D. at 5%	1.3	15	0.60	2.40	0.25	1.20	6.50
C.D. at 1%	1.7	20	0.80	3.10	0.34	1.58	8.50

*, ** Significant at 5% and 1% levels, respectively.

REFERENCES

- Anand Kumar, K., Jain R.P. and Singh S.D. 1983. *Plant Disease.*, 67 : 663.
- Burton, G.W. and Athwal, D.S. 1967. *Crop Science*, 7 : 209.
- Dave, H.R. 1987. Proceedings of the International Pearl millet workshop, ICRISAT, Patancheru. 121.
- Govila, O.P., Madhusudhana, R. and Unnikrishnan, K.V. 1997. *ISMN*. 38 : 116.
- Henna, W.W. 1989. *Crop Science*, 29 : 1457.
- Kempthorne O. 1957. *An Introduction to Genetic Statistics*. John Wiley and sons Inc. New York.
- Prakash, O., Singh, S. and Khairwal, I.S. 1987. *Crop Improvement*, 14 : 169.
- Safeeulla, K.M. 1977. *Annals of the New York Academy of Sciences*, 287 : 72.
- Yadav O.P., Manga V.K. and Gupta G.K. 1993. *Theoretical and Applied Genetics*, 87 : 558.

EFFECT OF AGRONOMIC PRACTICES ON GROWTH AND YIELD OF RAPESEED
(BRASSICA CAMPESTRIS L. SPP. OLEIFER (METZGER) SINSK. VAR. YELLOW SARSON)

ARUP GHOSH AND SUBHENDU MANDAL

*Department of Agronomy
Bidhan Chandra Krishi, Vishwavidyalaya
Mohanpur, Nadia, West Bengal - 741 252*

ABSTRACT

A field experiment was conducted during winter seasons of 2000-01 and 2001-2002 to study the effect of agronomic practices on rapeseed. Among the agronomic practices, fertilizer management was most important determinant in boosting the yield components and yield of rapeseed followed by water and weed management, respectively. Significantly highest yield components, yield and oil content were recorded with treatment (T₂), which received all improved package of practices and the lowest was obtained in control treatment.

Key words : Fertilizer, weed, water, yield and rapeseed.

India ranks second after China in the production of rapeseed and mustard. The country is grappling under shortage of edible oil. Continuous unabated rise in their price has further aggravated the situation. So, there is a need to increase the production of rapeseed and mustard. Horizontal expansion not being possible, it is very clear that the production has to be increased by enhancing the productivity. There is ample scope for increasing the productivity through proper planning and management of available resources like fertilizer, water and weed management.

Although yield improvements by individual management practices are well known, information on combined effect on growth and yield is meager. Therefore, an attempt was made to study the effect of agronomic practices on growth and yield of rapeseed.

MATERIALS AND METHODS

A field experiment was carried out during winter seasons of 2000-2001 and 2001-2002 at Central Research Farm, Gayeshpur, Nadia, West Bengal, in Entisol soil of neutral reaction having pH 7.6, total N 0.06%, available P and K 16.80

* Address for correspondence : P.B. No. 35, H.P.O., Nagaon - 782 001, Assam.

and 191 kg ha⁻¹, respectively. The experiment was laid out in randomized block design with three replications having 8 treatments, viz.,

- T₁ - Control (no fertilizer, water and weed management practices)
- T₂ - All improved agronomic practices
- T₃ - All improved agronomic practices without fertilizer management
- T₄ - All improved agronomic practices without weed management
- T₅ - All improved agronomic practices without water management
- T₆ - All improved agronomic practices without fertilizer and weed management
- T₇ - All improved agronomic practices without fertilizer and water management
- T₈ - All improved agronomic practices without water and weed management

For fertilizer management, 80 kg N, 60 kg P₂O₅ and 40 kg K₂O ha⁻¹ were applied through urea, single super phosphate and muriate of potash, respectively as per treatment. Full dose of P₂O₅ and K₂O and half dose of N were applied as basal and remaining N was top-dressed at 30

days after sowing (DAS). In case of weed management, two hand-weedings were done at 20 and 40 DAS. Two irrigations were applied at 30 and 60 DAS. Rapeseed cv. B-9 was sown at spacing of 30 cm × 10 cm in first week of November during both the years. Rainfall received during the crop growth period in 2000-2001 and 2001-2002 were 25.6 and 24.3 mm, respectively. Growth studies were made as per the standard procedures at 75 DAS and yield components and yield were recorded at harvest.

RESULTS AND DISCUSSION

Growth parameters

The agronomic practices resulted in significant variation in plant height, branches/plant and dry matter accumulation/m² (Table 1). In both the years of experimentation, significantly highest plant height, branches/plant and dry matter accumulation/m² were recorded where rapeseed was grown with all improved package of practices (T₂) and the lowest value were recorded in control (Rai *et al.*, 1993). The magnitude of reduction in plant height, branches/plant and dry matter accumulation was greatest in absence of fertilizer management followed by irrigation and water management, respectively.

The growth parameters recorded with all improved package of practices were almost same as recorded under the treatment receiving all improved package of practices without weed management. Similar result also reported by Bhadoria and Chauhan (1994).

Yield components

The yield components were also significantly influenced in both the years by the agronomic practices. The number of siliqua/plant, seeds/siliqua and 1000-seed weight recorded with the treatment receiving all improved package of practices were significantly higher over rest of the treatments.

The impact of fertilizer management in increasing the value of yield components was greater than water and weed management. Significantly highest reduction in the values of yield components except 1000-seed weight were recorded when fertilizer management was

excluded either individually or in combination with other agronomic practices. The results confirm the findings of Yadav *et al.* (1995). The lowest number of siliqua/plant, seeds, siliqua and 1000-seed weight in both the years were recorded when none of the improved agronomic practices were employed.

Yield and harvest index

The seed yield, stover yield and harvest index of rapeseed were significantly influenced in both the years by the agronomic practices. Significantly highest seed yield (1213 and 1226 kg/ha, respectively in 2000-2001 and 2001-2002) was recorded with the treatment receiving all improved agronomic practices and highest stover yield and harvest index was also recorded with the same treatment. The lowest seed as well as stover yield and harvest index was derived from the control treatment receiving no improved agronomic management practices.

The percentage increase in the seed yield of rapeseed recorded with the treatment receiving all improved agronomic practices (T₂) over the control treatment (T₁) were 132.8 and 110.3 in the respective years of experimentation. The reduction in the seed yield of rapeseed in both the years, respectively as compared to maximum yield was recorded due to withdrawal of fertilizer (75.0 & 74.9%), water management (43.2 and 44.1%) or weed management (21.5 and 21.0%) from full improved agronomic package of practices. This is agreement with the findings of Chauhan *et al.* (1996), Meena and Sumeriya (2002) and Singh, Kumar Aditya (2002).

The mean annual reduction in the seed yield, in both the years, due to withdrawal of fertilizer along with weed management, fertilizer along with water management and water along with weed management from all improved agronomic practices was 59.2, 71.2 and 48.9%, respectively compared to all improved agronomic practices.

Oil content

The agronomic practices resulted in significant variation in oil content of rapeseed (Table 1). Highest oil content was obtained in both the years with the treatment receiving all improved agronomic practices which was closely

Table 1. Effect of agronomic practices on growth, yield components and yield of rapeseed

Treatment	Plant height (cm) 75 DAS			Branches/plant			Dry matter accumulation (g m ⁻²)			Siliqua/plant			Seeds/siliqua		
	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean
T ₁	81.6	83.1	82.35	4.3	4.5	4.40	253.2	258.1	255.65	45.6	45.8	45.70	10.3	11.0	10.65
T ₂	108.3	109.9	109.10	11.8	11.5	11.65	417.9	419.1	418.50	104.7	103.9	104.30	25.6	27.8	26.70
T ₃	87.7	88.3	88.00	6.8	6.7	6.75	269.4	270.4	269.9	68.9	69.1	69.00	20.1	20.1	20.10
T ₄	101.4	102.9	102.15	10.6	10.6	10.60	389.4	391.6	390.50	96.4	96.8	96.60	21.3	21.8	21.55
T ₅	96.2	96.4	96.30	9.8	9.9	9.85	376.5	376.3	376.40	91.7	91.3	91.50	23.6	24.1	23.85
T ₆	84.9	84.6	84.75	6.2	6.2	6.20	261.5	262	261.75	61.6	61.5	61.55	14.5	15.0	14.75
T ₇	83.4	83.6	83.50	5.8	5.9	5.85	260.4	260.8	260.60	58.8	58.9	58.85	13.4	13.9	13.65
T ₈	89.6	88.9	89.25	8.6	8.9	8.75	366	265.8	315.90	86.3	86	86.15	20.8	20.2	20.50
C.D. (P=0.05)	2.3	2.3		1.0	1.1		21.7	21.9		9.9	9.9		0.7	0.7	

Treatment	1000-seed weight(g)			Seed yield (kg ha ⁻¹)			Stover yield (kg ha ⁻¹)			Harvest index (%)			Oil content (%)		
	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean	2000-01	2001-02	Mean
T ₁	2.1	2.1	2.10	521	583	552.00	2280	2502	2391.00	18.6	18.9	18.75	39.2	39.1	39.15
T ₂	2.8	2.8	2.80	1213	1256	1234.50	4038	4104	4071.00	23.1	23.0	23.05	44.8	44.9	44.85
T ₃	2.3	2.3	2.30	593	701	647.00	2789	2769	2779.00	19.9	20.2	20.05	40.6	40.8	40.70
T ₄	2.6	2.7	2.65	998	1013	1005.50	3379	3469	3424.00	22.8	22.6	22.70	44.0	44.1	44.05
T ₅	2.4	2.5	2.45	847	851	849.00	3003	2998	3000.50	22.0	22.1	22.05	40.5	41.0	40.75
T ₆	2.2	2.2	2.20	762	770	766.00	3029	3080	3054.50	20.1	20.0	20.05	40.9	40.8	40.85
T ₇	2.1	2.2	2.15	709	716	712.50	2853	2900	2876.50	19.9	19.8	19.85	40.1	40.4	40.25
T ₈	2.4	2.4	2.40	818	821	819.50	3004	2998	3001.00	21.4	21.5	21.45	43.8	43.7	43.75
C.D. (P=0.05)	0.4	0.4		106.4	112.1		217.1	224.4		0.9	0.9		1.1	1.1	

followed by that obtained by the treatment receiving all improved agronomic practices except weed management.

The lowest oil content was recorded in the control treatment. The magnitude of reduction in oil content was greatest in absence of fertilizer management either individually or in combination with other agronomic practices like

water and weed management, respectively. Bhadoria and Chauhan (1994) also noted reduction of oil content in absence of fertilizer.

Therefore, it is evident from the result that fertilizer management is most important in boosting the productivity of rapeseed followed by water and weed management, respectively.

REFERENCES

- Meena, B.S. and Sumariya, H.K. 2002. Proc. 22nd *International Security - A Continuing Challenge* held on November, 26-30, 2002, New Delhi : 285-286.
- Chauhan, D.R. Paroda, S. and Ram, M. 1996. *Indian J. Agron.*, **41**(4) : 620-623.
- Singh, Kumar Aditya 2002. *Journal of Oilseed Research*, **17**(1) : 117-12.
- Yadav, N.S. Rajpur, R.L. Tomar, S.S. and Verma, O.P. 1995. *J. Oilseeds Res.*, **21**(1) : 24-29.
- Bhadoria, R.B.S. and Chauhan, D.V.S. 1994. *Indian J. Agron.*, **39**(4) : 690-699.
- Rai, B. Singh, R.P. Yashwant, Singh, Singh, S.R. and Singh R.K. 1993. *Indian Farming*, **43**(3) : 3-6.

LINE X TESTER ANALYSIS FOR FODDER YIELD AND QUALITY COMPONENTS IN MULTICUT FORAGE SORGHUM

K. IYANAR AND A.K. FAZLLULAH KHAN

*Centre for Plant Breeding and Genetics
Tamil Nadu Agricultural University, Coimbatore-641 003*

ABSTRACT

Combining ability effects and variances were estimated in F₁ over four different environments. Significance of environments vs genotypes for all the characters except stem thickness was observed. Predominance of additive gene action was observed for plant height, number of leaves, leaf length and leaf breadth. Crude protein and green fodder yield/plot were found to be under the control of non-additive gene action. Based on the gca and high mean values, the parents 111A, 68726, 68786 and SS032 could be identified as the best parents for developing almost all the forage characters with multicut habit. Selection based on the per se, sca and standard heterosis in relation to their parental status, four hybrids viz., 111A × 68814, 111A × FS 9605, 111A × 68724 and 111A × 68726 were selected with additive × additive type of gene action for green fodder yield/plot. The hybrids 111A × 68786 for crude protein, and 111A × FS 9604 for low HCN content were found to have dominance × dominance type of gene action.

Key words : Line × Tester analysis, fodder yield, quality, multicut forage sorghum.

A comprehensive understanding on the genetic architecture of the parents, knowledge on the combining ability of parents and hybrids, identification of superior hybrid combinations favorably interesting with environments for fodder yield and quality characters are the essential needs of a forage breeder for implementing a systematic crop improvement programme for developing a new multicut hybrid sorghum. The present investigation was oriented towards eliciting basis and applied information on the above aspects and to formulate a breeding strategy to be adopted in forage sorghum with special reference to the set of materials involved, through line x tester analysis.

MATERIALS AND METHODS

The materials comprised of eighty-four F₁ hybrids resulting from four lines and twenty one testers of different origin with multicut habit. All these hybrids and parents were raised in a randomized block design with three replications by adopting 30 cm × 15 cm spacing during summer 2000. All the agronomic practices were

followed to maintain the crop stand. The biometrical observations on fodder yield and quality components were recorded for each genotypes in all replications at the time of 50 per cent flowering. The replication wise mean values of the genotypes were tabulated. After completion of first cut, the same experimental materials were allowed to grow as a ratoon crop. Similar package of practices was followed as that of first crop and at the time of 50 per cent flowering biometrical observations were taken and tabulated. In the same way third and fourth cuts were allowed to study the ratooning ability/ multicut habit of the experimental materials observations were taken on each cut and were tabulated and subjected to line x tester pooled analysis over environment of combining ability developed by Kempthorne (1957).

RESULTS AND DISCUSSION

The estimate of GCA and SCA variances are useful to inter the type of gene action and the relative importance of the character in a breeding programme. In addition, the ratio between GCA and SCA variances help to find out the extent of

additive gene action. The estimate of combining ability variances showed higher values of GCA variances SCA variances for plant height, number of leaves, leaf length, leaf breadth in all the environments and pooled data over environments indicated the predominance of additive gene action for these characters. Predominance of SCA variance was observed for crude protein and green fodder yield per plot indicating that these traits are mainly controlled by non-additive gene action as reported by Paroda *et al.* (1978). The significant values of environmental variance indicated that there was sufficient variability between the environments for most of the characters viz, plant height, leaf length, leaf breadth, stem thickness, crude protein and green fodder yield per plot indicating differential response of environment on each characters. Significance of environments Vs genotypes for all the characters except stem thickness was observed.

The primary criterion for the choice of desirable parents was on the basis of performance of inbreeds for their high expression of mean and general combining ability for various trait (Kadanbavana sundaram, 1982). The gca effects are presented in Table 1. In the present study positive association between per se performance and gca effects was evident for 111A for all the characters except crude protein and hydro cyanic acid (Table 2). Among the testers 68786 recorded high per se values and gca effects in desirable direction for all the characters except crude protein. It also recorded higher gca effect and lower mean values for total soluble solids. The parents 68724 and 68726 recorded in higher per se values coupled with high gca effect for green fodder yield per plot. The above results pointed towards a positive relationship between per se performance and gca effects. Probably these parents may have more number of additive genes and could contribute for the accumulation of favorable genes in a varietal development programme.

For the characters like hydro cyanic acid, number of leaves, leaf length, leaf breadth, total soluble solids and crude protein, most of the parents had either low mean with high gca effect

of vice versa except in a few cases like 68786, 68814, SS032, FS 9401 for hydrocyanic acid, FS 9604 for total soluble solids and SRV 605 for crude protein. The lack of correspondence between gca effects of some of the parents and their per se performance indicated that in these parents the particular trait was probably under the influence of non-additive gene action. On over all consideration based on the gca and high mean values the parents 111A 68786, 68726 and SS032 could be the best for developing almost all the forage characters with multicut habit. Chawla and Gupta (1982) indicated that such parents could produce transgressive segregants on the F_2 as well as in later generations. The remaining parents can be used in recombination breeding. In general, it would be desirable to develop multiple crosses to select desirable segregants for yield and favourable associated traits in advanced generations, as no parent was a good general combiner for all the traits especially for more harvest or multicut types as reported by Pooranchand (1996).

The sca effects along with per se performance of the hybrids can give an idea about the practical utility of the hybrid combinations for heterosis breeding. It was evident from the hybrids like 111A $\times$ FS 9605, which had high per se performance with high sca effects for plant height, total soluble solids and green fodder yield per plot. Similarly, 111A $\times$ 68740, 111A $\times$ 68726, 111A $\times$ SS032 recorded high per se and sca effects for green fodder yield per plot. Selection based on the per se, sca effects and standard heterosis in relation to their parental status can also give some idea about the nature of gene action involved in the cross and to develop an appropriate breeding methodology for developing such hybrids as it was evident that high $\times$ high general combiners produced hybrids with high per se performance with significant sca effects and substantial heterosis. This was observed in the crosses of 111A $\times$ 68814, 111A $\times$ FS 9605, 111A $\times$ 68724 and 111A $\times$ 68726 for green fodder yield. This nature of hybridity indicates the importance of additive $\times$ additive gene action, which could be exploited to derive recombinant homozygous lines through standard selection procedure.

Table 1. Green combining ability effects for different characters

Parents	Plant height	No. of leaves	Leaf length	Leaf breadth	Total soluble solids	Crude protein	Hydrocyanic acid	Green fodder yield/plot
Lines								
296A	-17.349**	-0.495**	-0.387	0.115*	0.457**	-0.144**	14.877**	-3025**
2219A	-6.974**	-0.438**	-1.395**	-0.571**	0.453**	0.536**	-3.577**	1.484**
2077A	15.575**	0.504**	1.368**	0.093	-0.864**	-0.221**	-12.661**	-1.565**
111A	5.748**	0.429**	0.415	0.363**	-0.047	0.171**	1.341**	3.105**
SE(g _i)	0.377	0.052	0.367	0.049	0.073	0.012	0.371	0.071**
Testers								
68716	6.658**	0.095	1.034	-0.018	-1.090**	-0.025	9.530**	0.591**
68740	14.324**	0.257*	-0.157	0.060	-0.538**	0.565**	26.009**	0.333*
69918	-22.347**	0.327**	1.642	0.661**	0.965**	0.303**	6.558**	-1.033**
68786	8.588**	0.419**	1.862*	0.144	-1.642**	-0.136**	-7.841**	-0.123
68814	12.502**	0.492**	5.621**	-0.015	-0.059	0.47**	13.132**	3.225**
FS211	-15.024**	-0.132	-0.281	0.192	0.441**	0.012	9.786**	0.668**
FS205	8.957**	0.241*	-2.206**	0.275*	-0.163	0.084**	-17.261**	-1.416**
FS9401	5.163**	0.126	-0.937	0.071	-0.642**	-0.42**	1.246	1.466**
SS003	-14.689**	-0.056	-1.006	0.112	-0.059	-0.135**	-6.465**	-0.335*
SS012	-17.052**	0.21	-5.686**	-0.005	-0.100	0.412**	6.452**	-1.417**
SS020	21.149**	0.214	3.970**	0.073	-0.163	0.04	-9.096**	-0.105
SRV605	-6.505**	-0.232*	-2.564**	-0.233*	-0.704**	-0.506**	7.499**	-0.513**
FS9604	-18.939**	0.149	-2.391**	0.201	0.546**	0.586**	6.246**	-2.773**
FS9605	7.595**	-0.210	1.988*	-0.280*	1.108**	0.018	-16.469**	1.627***
FS9601	8.410**	-0.325**	-2.017*	-0.267*	0.712**	-0.53**	-7.608**	1.792**
FS9603	-9.012**	-0.588**	-2.158*	-0.152	0.004	-0.507**	30.831**	-3.354**
68710	-1.465	-0.247*	4.548**	0.078	0.650**	-0.332**	-7.393**	-3.23**
68724	11.960**	0.287*	4.604**	-0.241*	0.629**	0.171**	0.513	3.552**
68726	10.813**	-0.156	1.520	-0.693**	0.858**	-0.229**	-12.195**	2.278**
Co27	-2.918**	-0.204	0.531	-0.136	0.691**	0.164**	-3.444**	0.182
SS032	-8.169**	-0.225	-4.631**	0.174	0.483**	-0.004	-3.765**	-0.233
SE(g _i)	0.864	0.118	0.841	0.112	0.167	0.028	0.850	0.164

* Significant at 5% level.

** Significant at 1% level.

Table 2. Best parents and hybrids selected on the basis of per se performance, gca and sca effects

Sl.No.	Characters	Best parents based on per se and gca effects	Best parents based on per se and sca effects
1	Plant height	111A, 68786, 68814, SS020, 68740 and 68726	2077A × 68814, 2077A × 68726, 2219 A × 68716, 111A × 68740 and 111A × FS 9601
2	Total soluble solids	FS 211 and FS 9604	296A × FS 9601, 296A × 68724, 296A × 68726 and 111A × FS 9605
3.	Crude protein	CO 27	2219A × FS 9604, 296A × FS 205, 2219A × 68710, 20777A × 68814, 111A × FS 9604 and 296A × 68716
4	Hydrocyanic acid	SS032, SS003 and 68814	296A × SS003, 2219A × FS 9605, 2077A × SS032 and 111A × 68786 and 111A × FS 205
5	Green fodder yield/plot	111A, 68724 and 68726	111A × 68726, 111A × 68724, 111A × SS032, 111A × 68814, 111A × SRV 605, 111A × FS 205, 2077A × FS 9605, 2219A × 68726 and 296A × FS 9601

The hybrids 111A × 68726 and 111A × 68786 for crude protein and 111A × FS 9604 for low HCN content, showed high per se performance and significant sca effects with desirable heterosis but with row general combiners, indicating dominance × dominance type of gene action and the above said crosses for the above characters could also be utilized in the production of high yielding homozygous lines as viewed by Reddy and Joshi (1993) because of the non availability of optimum level of different attributes in any of the parents. In conclusion on the basis of per se performance, sca effects and heterosis. 111A × 68726 exceeded in all other hybrids in respect of green fodder yield per plot and it could be used for further direct exploitation for developing multicut hybrid.

REFERENCES

- Chawla, H.S. and Gupta V.P. 1982. Seasonal effects on combining ability in pearl millet. *Indian J. Genet.*, 42 : 137-142.
- Kadombavana Sundaram, M. 1982. Concept of combining ability and its impact on breeding procedures. Proceeding of the summer institute on "Theoretical and applied aspects of exploiting heterosis in crop plant", TNAU, Coimbatore, pp. 1-9.
- Kempthorne, O. 1957. An introduction to Genetical statistics. John Willey and Sons. Inc. New York.
- Paroda, R.S., Lodhi G.P. and Grewal R.P.S. 1978. Line × Tester analysis for combining ability in forage Sorghum. *Forage Res.*, 4 : 31-41.
- Pooran Chand. 1996. Combining ability in winter sorghum. *Madras Agric. J.*, 83 : 573-575.
- Reddy, J.N. and Joshi P. 1993. Heterosis, inbreeding depression and combining ability in Sorghum. *Indian J. Genet.*, 53 (2) : 138-146.

STABILITY ANALYSIS IN FRENCH BEAN (*PHASEOLUS VULGARIS* L.)

U.P. PANDEY, G. PRASHAD AND SUDHAKAR PANDEY*

Shri Durga Ji Post Graduate College, Chandesar, Azamgarh (U.P.)

ABSTRACT

Thirtyfive genotypes of french bean were evaluated with three replications in randomized block design. Four nitrogen regimes viz., E1 (0 kg), E2 (50 kg), E3 (100 kg) and E4 (150 kg) and two years constituted eight environments. Stability analysis for days to 50% flowering, plant height, branches per plant, pods per plant, pod length, seeds per pod, 100 seed weight and seed yield per plant was done by Eberhart and Russell models. Significant $G \times E$ interaction was observed for all the traits except branches per plant. Genotypes DPR-90-14 and PDR-14 were found stable for seed yield. None of these genotypes were found stable for all the characters over all the environments.

Key words : Frenchbean, stability.

French bean (*Phaseolus vulgaris* L.) is a multipurpose crop because of its green pod and dry seed which are used as vegetable and various preparations. Being a leguminous crop, it is rich in protein and minerals. The requirement of nitrogen in this crop is much more than other leguminous crops because it does not nodulated. Plant breeders while developing improved cultivars, are often confronted with the problem of interpreting genotype $\times$ environment interaction evidenced by different in the relative rankings of crop cultivars when compared over a series of environments. The large $G \times E$ interactions for a quantitative trait tend to reduce the usefulness of genotypic means. In French bean, most of the present day popular varieties are introductions and they usually show inconsistent yield and lack of stability.

The major experiments related to stability in French bean have been done for location, year and seasons effects on genotypes. However, no information is available on stability of genotypes under different fertility regimes over the year to the growers. Keeping this objective in view, the present investigations were under taken to identify stable and high yielding varieties possessing under the varying factors of environments.

*Scientist, Indian Institute of Vegetable Research, Varanasi.

MATERIALS AND METHODS

The experiment was conducted at SDJPG College, Chandesar, Azamgarh. Four nitrogen levels viz., 0kg, 50 kg, 100 kg and 150 kg were applied through urea as basal and top dressing. Half amount of urea was applied as basal and of remaining half into splits doses. Four doses of nitrogen level and two years constituted the eight environments. Each genotype was sown in 3 rows of 1.5 meter length in each replication with row to row and plant to plant spacing 30 cm, and 10 cm, respectively. Five random plants of each genotype were selected to recording the observations for days to 50% flowering, plant height (cm) number of branches per plant, pods per plant, and pod length (cm) seeds per pod, 100-seed weight (g) and seed yield per plant (g). The data were subjected to pooled analysis of variance Panse (1957) and estimation of stability parameters by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The analysis of variance for each environment as well as pooled analysis of variance revealed significant differences for the character studied. The stability parameters indicated significant differences among genotypes as well as environments. Genotypes $\times$ environment interactions were significant for all the character except number of branches per

plant. Similar results were reported by many investigators; Santos *et al.* 1982, Beaver *et al.* (1985) and Vaid *et al.* (1985) have reported significant $G \times E$ interaction for seed yield and most of the component traits. The linear component of environment and pooled deviation were significant for all the characters.

The genotypes were categorized into various stability groups on the basis of mean, regression coefficient and deviation from regression coefficient. The genotypes having high mean, unit regression ($b_i = 1$) and deviation from regression as small as possible ($S^2 d_i = 0$) and average stability. Further the genotype with high mean, $b_i > 1$ and $S^2 d_i = 0$ are considered more responsive for favourable environments. Whereas, the genotypes with high mean, $b_i < 1$ and $S^2 d_i = 0$ or expected to equal to exceed average mean performance is suitable under unfavorable environments. Michaels and Stanley (1991) found that well adopted variety had regression coefficient approaching (0) zero for most of its yield components. The stability parameters for days to 50% flowering (Table 1) indicated that HUR-14, HUR-126 and VL-63 were stable for a wide range of environments. HUR-91 was expected to show superior performance only favourable environments while, DPR-87-33 and DPR-87-43 and suitable for low yielding environments. Genotype HUR-68 was found stable for plant height, whereas HUR-328 and HUR-400 were performing well under good environment. For number of branches per plant genotypes DPR-90-14, HUR-126, HUR-199, HUR-326, HUR-349, HUR-408 and HUR-490 were found stable. DPR-87-33, HUR-136, HUR-364, HUR-365 and HUR-542 are considered more responsive for favourable environments; While PDR-14, HUR-120, HUR-135, HUR-350, and HUR-488 were suitable for unfavorable environments for number of branches per plant. For pods per plant none of the genotypes were found stable. DPR-87-33, PDR-14, HUR-14 and HUR-126 were suitable under good environments. HUR-120, HUR-364, HUR-400 and VL-63 were suitable for poor environments. Genotype HUR-68, HUR-121, HUR-135 and HUR-349 were stable over the environments for pod length, while HUR-136, HUR-199, HUR-291,

Table 1. Stability analysis for days to 50% flowering, plant height, number of branches/plant and number of pods/plant

Genotypes	Days to 50% flowering			Plant height (cm)			Number of branches/plant			Number of pods/plant		
	xi	bi	S ² di	xi	bi	S ² di	xi	bi	S ² di	xi	bi	S ² di
DPR-86-6	52.33	0.93	-0.34	21.37	-0.09	4.24	3.53	0.92	0.14	6.92	1.36	1.68
DPR-87-33	54.00	0.32	0.64	22.21	0.06	4.71	3.70	1.21	0.04	6.95	1.18	0.68
DPR-87-43	54.17	0.16	0.39	25.25	0.33	2.06	3.88	1.15	0.39	8.24	1.67	3.60**
DPR-90-6	52.79	0.77	0.00	27.17	0.51	5.72	4.35	1.51	0.51*	7.51	1.74	3.63**
DPR-90-14	52.00	1.27	-0.23	23.83	0.80	5.49	3.93	0.90	0.35	7.75	1.95	3.75**
DPR-14	59.17	2.92	4.64*	27.75	1.56	2.24	3.99	0.58	0.05	8.49	1.47	0.71
HUR-120	52.72	0.73	1.65	27.00	1.40	-5.54	3.89	0.46	0.18	6.56	0.59	0.71
HUR-136	51.00	0.91	-0.17	28.17	0.59	-0.30	3.84	1.28	-0.05	5.80	1.04	-0.14
HUR-137	50.54	0.75	-0.37	28.33	0.69	-2.92	3.66	0.95	0.02	5.88	1.17	0.97
HUR-14	53.58	0.92	-0.01	32.58	-0.21	12.61	3.77	1.01	0.07	6.44	1.23	-0.01

Contd...

Table 1 contd...

HUR-41	73.96	6.10	23.10**	104.08	5.17	366.15**	2.73	0.18	0.10	9.81	1.36	4.02**
HUR-61	53.21	1.53	38.45**	35.29	1.01	463.30**	3.49	0.54	0.16	5.65	0.95	1.12
HUR-68	52.46	0.99	-0.17	30.25	0.93	2.83	3.25	1.14	-0.02	5.38	1.13	0.13
HUR-91	53.58	1.25	-0.25	26.38	1.27	-1.88	3.42	0.92	-0.03	4.61	0.89	-0.20
HUR-121	50.33	0.95	4.44	25.29	1.46	1.24	3.53	1.05	-0.01	5.33	0.94	-0.07
HUR-126	55.04	0.98	2.29	28.21	1.70	0.61	3.90	0.96	0.03	7.10	1.83	0.94
HUR-134	52.21	0.90	1.50	24.83	0.77	-3.60	3.72	0.49	0.01	4.64	0.57	0.17
HUR-135	50.46	0.31	2.06	24.33	1.63	-5.24	3.85	0.80	-0.04	5.23	1.09	-0.25
HUR-199	50.33	0.51	10.40**	25.12	1.06	-5.24	3.93	1.09	0.04	5.23	0.87	0.16
HUR-291	50.67	0.78	-0.21	23.96	0.49	4.58	3.60	0.85	-0.01	5.58	0.64	0.72
HUR-298	50.71	0.61	10.37**	26.58	0.59	-1.22	3.50	1.43	0.11	4.99	0.77	0.39
HUR-326	52.75	1.10	1.16	28.79	0.95	-4.53	3.93	1.06	0.07	6.09	1.08	1.40
HUR-328	52.04	0.49	-0.02	29.33	1.79	-4.22	3.67	1.30	-0.04	5.83	0.95	-0.24
HUR-329	52.96	0.60	0.14	26.62	1.59	-2.77	3.61	1.09	-0.05	4.92	0.69	-0.31
HUR-349	51.92	1.10	3.29	26.04	0.56	-5.08	3.90	0.95	-0.04	5.36	0.71	-0.18
HUR-350	52.67	1.82	1.09	25.96	0.47	-2.70	3.80	0.65	0.00	5.88	0.39	0.14
HUR-354	52.75	0.62	-0.35	28.58	0.57	-2.02	3.72	1.17	0.1	5.93	0.52	0.66
HUR-364	52.83	0.16	1.06	28.75	0.83	-3.64	4.16	1.68	0.00	7.17	0.86	0.04
HUR-365	51.42	1.23	1.99	28.92	0.46	-4.24	3.87	1.56	-0.06	5.99	0.74	0.01
HUR-400	51.50	0.78	-0.13	29.13	1.44	-4.81	3.73	1.39	0.09	6.33	0.75	0.91
HUR-408	51.00	-0.05	-0.45	23.83	0.58	0.67	3.81	0.89	0.07	7.28	1.22	1.04
HUR-488	52.25	0.74	-0.20	27.96	0.98	1.18	3.96	0.87	0.08	6.72	0.73	1.79
HUR-490	49.67	-0.42	0.53	28.08	1.44	-2.56	3.81	1.08	-0.04	6.07	0.62	-0.03
HUR-542	52.12	1.19	0.08	25.33	1.16	-4.15	3.89	1.37	0.02	5.72	0.61	0.21
VL-63	53.75	1.11	-0.07	21.46	0.47	-2.96	3.56	0.52	0.13	7.27	0.69	0.61
Mean	53.00	1.00		29.05	1.00		3.74	1.00		6.31	1.00	
SE ±	0.72	0.54		2.05	0.95		0.14	0.36		0.41	0.28	

* P = 0.05, ** P = 0.01.

Table 2. Stability parameters for pod length, seeds/pod, 100 seed weight and seed yield/plant

Genotypes	Days to 50% flowering			Plant height (cm)			Number of branches/plant			Number of pods/plant		
	xi	bi	S ² di	xi	bi	S ² di	xi	bi	S ² di	xi	bi	S ² di
DPR-86-6	17.49	1.09	0.74	6.04	1.25	0.25	7.90	0.73	1.07	7.47	0.57	1.36
DPR-87-33	16.51	1.35	0.85	5.73	1.23	0.05	7.42	0.72	0.38	7.28	0.85	1.72
DPR-87-43	16.77	0.96	0.17	5.80	1.06	-0.18	8.01	0.86	0.45	8.21	0.69	4.46**
DPR-90-6	22.81	0.84	2.43	6.88	1.56	0.90	9.23	1.31	0.74	9.02	0.83	6.30**
DPR-90-14	17.74	1.70	0.59	6.34	1.41	0.03	8.42	1.48	0.61	8.64	0.98	1.97
DPR-14	17.78	0.75	0.46	6.26	0.90	0.12	8.42	1.65	-0.02	9.82	0.98	0.45
HUR-120	21.05	1.53	4.76**	6.90	1.56	0.11	8.67	1.59	-0.92	8.81	1.44	1.18
HUR-136	21.00	1.44	1.15	6.56	1.59	0.59	9.29	1.03	0.59	7.45	1.18	0.52
HUR-137	21.39	1.21	0.16	7.19	1.06	0.08	8.76	1.63	0.30	7.51	1.35	0.60
HUR-14	19.86	1.04	0.29	6.13	1.18	-0.08	9.09	0.65	0.37	7.64	1.45	-0.08
HUR-41	15.68	0.19	2.29	6.94	0.22	0.14	4.57	0.17	1.39*	7.20	1.36	2.16
HUR-61	19.74	0.65	4.19*	6.20	1.18	0.61	9.21	0.87	1.84*	7.28	0.71	3.65**
HUR-68	20.95	0.91	0.22	6.60	1.34	0.08	9.61	0.26	1.40*	7.84	1.14	1.56
HUR-91	22.26	0.64	0.32	7.15	1.04	0.32	9.83	0.38	0.21	7.22	1.13	1.34
HUR-121	21.88	0.91	0.37	6.51	1.29	0.37	9.82	0.47	0.41	7.48	0.91	1.12
HUR-126	18.73	0.85	1.26	6.69	0.59	1.04	7.06	0.99	0.52	7.14	0.81	1.28
HUR-134	21.80	0.82	1.14	7.27	0.96	0.43	9.33	1.62	0.60	7.72	1.29	3.94**
HUR-135	21.56	1.04	-0.14	7.62	0.71	0.02	9.25	1.24	0.51	8.40	1.20	0.80
HUR-199	21.13	1.62	0.20	6.63	1.53	-0.03	9.75	0.59	0.48	7.08	1.05	0.55
HUR-291	20.62	1.29	0.13	7.46	1.15	0.02	7.12	0.96	0.29	7.02	0.83	2.50
HUR-298	20.52	1.34	0.56	6.92	1.27	0.11	9.33	1.37	0.14	6.68	0.96	1.01
HUR-326	19.66	0.81	0.42	6.51	0.52	1.42*	7.69	0.38	0.89	6.31	0.85	0.20
HUR-328	19.92	0.90	0.56	7.29	0.49	0.00	6.65	1.29	0.86	6.29	0.72	0.00
HUR-329	20.12	1.21	-0.17	7.18	0.96	0.13	8.81	1.03	0.35	6.88	0.84	0.08
HUR-349	20.31	0.93	0.12	7.74	0.82	-0.12	7.32	0.82	0.45	7.03	0.91	0.80

Contd...

Table 2(b) contd...

HUR-350	21.58	1.19	0.81	6.88	1.02	0.06	8.34	1.09	0.15	7.25	1.14	2.22
HUR-354	20.15	0.43	0.61	7.05	0.19	-0.01	7.07	1.49	1.27*	6.83	0.44	0.88
HUR-364	18.98	0.87	0.11	6.80	0.59	-0.10	6.92	1.19	0.45	6.79	0.95	0.05
HUR-365	20.10	0.66	-0.35	7.37	0.53	-0.11	7.91	1.34	0.96	7.22	0.86	0.89
HUR-400	20.00	0.88	-0.35	7.54	0.76	-0.02	7.00	1.15	0.95	6.94	0.99	4.27**
HUR-408	20.70	1.16	-0.37	7.25	1.28	0.53	6.14	1.26	0.59	7.52	1.56	1.94
HUR-488	19.60	0.80	0.13	7.45	0.67	0.26	6.92	0.95	0.56	7.86	1.15	2.63*
HUR-490	20.54	1.40	2.19	6.86	1.24	-0.01	8.85	0.86	0.14	7.85	1.14	1.03
HUR-542	22.60	0.86	0.49	7.84	1.16	0.35	8.47	1.46	0.23	7.98	1.29	2.59*
VL-63	17.98	0.75	3.11	6.72	0.74	0.39	7.53	0.15	-0.07	7.72	0.64	1.88
Mean	19.99	1.00		6.87	1.00		8.16	1.00		7.52	1.00	
SE ±	0.44	0.20		0.25	0.15		0.33	0.59		0.54	0.21	

* P = 0.05, ** P = 0.01.

HUR-298, HUR-329, HUR-350 and HUR-408 were suitable for favourable environment. Five genotypes viz., HUR-91, HUR-134, HUR-354, HUR-365, HUR-400 and HUR-542 were suitable for poor environments. For seeds per pod genotypes HUR-91, HUR-134, HUR-137, HUR-329 and HUR-350 were found stable. Six genotypes viz., PDR-90-6, HUR-120, HUR-291, HUR-298, HUR-408 and HUR-542 were performing well under good environment. Whereas, genotypes, HUR-41, HUR-135, HUR-328, HUR-349, HUR-354, HUR-365, HUR-400 and HUR-488 were suitable for poor environments. For 100 seed weight HUR-136, HUR-329 and HUR-350 were found stable. Nine genotypes were suitable for good environments, while, genotypes HUR-14, HUR-91, HUR-121, HUR-199 and HUR-490 were found suitable for poor environments. For seed yield per plant DPR-90-14, and PDR-14 were suitable for a wide range of environment. Genotype HUR-14, and PDR-14, were suitable for a wide range of environment. Genotype HUR-14, HUR-68, HUR-120, HUR-135, HUR-408 and HUR-490 were suitable for good environment, while VL-63 was better suited for low yielding environment. Castillo (1984) identified 16 varieties as most stable but only 8, 5 and 9 of them give high seed yield, 100-seed weight and number of pods per plant, respectively. Genotype, DPR-90-14 was stable for number of branches per plant and seed yield per plant. None of these genotypes were found stable for all the characters over all environments. Similar observation was recorded by Pandey *et al.* (2000).

REFERENCES

- Beaver, J.S., Paniagua, C.V., Coyne, D.P. and Freytag, G.F. 1985. Yield stability of dry bean genotypes in the Dominican Republic. *Crop Sci.*, **25** : 923-926.
- Castillo, R.M. 1984. Yield stability of French bean (*Phaseolus vulgaris* L.) in the most Temperate Zone of Mexico. *Agricultura Technicae*, **10**(2) : 133-151.
- Eberhart, S.A. and Russell, W.A. 1996. Stability parameters for comparing varieties. *Crop Sci.*, **6** : 36-40.
- Michaels, T.E. and Stanley, D.W. 1991. Stability and inheritance of storage induced hardening in 20 common bean cultivars. *Canadian J. Pl. Sci.*, **71** (3) : 641-647.
- Pandey, Sudhakar, Dixit, J., Dwivedi, S.V. and Dubey, R. 2000. Stability analysis for yield and its components in Tomato. *Haryana J. Hort. Sci.*, **29**(3&4) : 207-208.
- Pansey, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet.*, **28** : 225-229.
- Santos, J.B., Vello, N.A. and Ramaho, M.A.P. 1982. Stability of grain yield and of its basis components inbred (*Phaseolus vulgaris* L.). *Revista Brasileira De genetica*, **5**(5) : 761-772.
- Vaid, K., Gupta, V.P. and Singh, R.M. 1985. Stability analysis in dry beans. *Crop Improv.*, **12** : 28-31.

COMBINING ABILITY ANALYSIS FOR YIELD AND ITS COMPONENTS IN HYBRID RICE

ANAND KUMAR, N.K. SINGH AND V.K. CHAUDHARY

*Department of Plant Breeding
Rajendra Agricultural University, Bihar, Pusa-848 125 (Samastipur)*

ABSTRACT

Twenty seven hybrids generated from crossing three CMS lines with 9 testers were studied along with the parents for combining ability for days to 50% flowering, days to maturity, plant height, number of effective tillers hill⁻¹, panicle length, sterility %, 1000-grain weight and grain yield plant⁻¹. Among the male parental lines, Pusa 1040 and PSRM-1-16-48-1 appeared as a whole, the best general combiner for yield and its component traits. The female line IR 58025A was a good combiner for grain yield plant⁻¹ and its major components. The most promising specific combinations were IR 68886A × Pusa 1040, IR 58025A × Gautam and IR 68886A × PSRM-1-16-48-1.

Key words : Rice, combining ability, line × tester, yield components.

Combining ability is a measure of gene action (additive and non-additive). General combining ability largely involves additive gene effects, whereas specific combining ability represents only non-additive gene-action. The specific combining ability is a measure of dominance variance. The choice of parents, especially for heterosis breeding, should be based on the combining ability test and their mean performance (Yadav and Murty, 1966). The present investigation was aimed to analyze the combining ability of three CMS lines with 9 varieties/lines.

MATERIALS AND METHODS

The experimental material comprised of hybrid progenies derived from 27 crosses generated through line × tester mating design. Three cytoplasmic male sterile lines viz., IR 58025A, IR 68897A and IR 68886A possessing wild abortive (WA) type of cytoplasm were used as lines and nine diverse varieties/lines viz., Gautam, Dhanlaxmi, Prabhat, Saroj, Pusa 1107, Pusa 1040, PSRM-1-16-48-1, RAU 1411-4 and RAU 1411-10 were used as testers. The F₁ hybrids along with their respective parents were grown in randomized block design with three replications at Research Farm, RAU, Pusa during

2001. Thirty day-old seedling were transplanted with a 20 cm × 15 cm spacing. Each test entry consisted of single row of 2 m length.

The observations were recorded on five plants plot⁻¹ selected at random from each treatment in each replication for days to 50% flowering, days to maturity, plant height, no. of effective tillers hill⁻¹, panicle length, sterility %, 1000-grain weight and grain yield plant⁻¹. The combining ability analysis was carried out as suggested by Kempthorne (1957) and elaborated by Arunachalam (1974).

RESULTS AND DISCUSSION

The analysis of variance for combining ability for yield and yield components revealed significant differences among the genotypes. Combining ability variance due to lines, testers and line × tester were significant for all the characters. The variance due to interaction between line × tester were highly significant for all the characters indicating the presence of adequate variability in the experimental material.

The concept of combining ability is a measure of gene action i.e., additive and non-additive. General combining ability effects largely involves additive gene action, whereas

Table 1. Estimates of general combining ability (gca) effects of parents for eight characters in rice

Parquet	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers hill ⁻¹	Panicle length (cm)	Sterility (%)	1000-grain weight (g)	Grain yield plant ⁻¹ (g)
Lines								
IR 58025A	-0.04	-0.53	9.69**	-1.18**	1.65**	-3.35**	0.12	7.72**
IR 68897 A	1.04**	1.21**	-6.82**	0.93**	-0.33	-0.65	0.21	-5.55**
IR 68886A	-1.00*	-0.68	-2.87**	0.25	-1.32**	4.00**	-0.34**	-2.17**
S.E. (±)	0.38	0.37	0.34	0.25	0.25	0.93	0.12	0.78
C.D. (L) at 5%	1.07	1.04	0.95	0.71	0.69	2.60	0.34	2.17
C.D. (L) at 1%	1.40	1.38	1.25	0.93	0.90	3.42	0.45	2.86
Testers								
Gautam	-3.92**	-0.68**	0.56	0.64	0.13	25.35**	0.70**	-9.95**
Dhanlaxmi	3.29**	3.10**	-9.81	-0.36	-2.06**	-9.11	-0.08	-3.00*
Prabhat	-2.15**	-2.12**	-7.90	-2.41**	-2.35**	-9.65**	1.47**	-10.17**
Saroj	-0.26	0.77	-5.58**	-0.84	-1.02	3.39	-0.80**	-7.50**
Pusa 1107	1.96**	1.54**	-0.71	2.40**	0.94*	-4.48**	-0.30	-5.53**
Pusa 1040	1.40**	1.65*	1.80**	0.83	0.74	15.22**	-0.08	12.66**
PSRM-1-16-48-1	0.96*	0.54	1.55**	2.45**	1.04*	-13.79**	-0.69**	9.77**
RAU 1411-4	-1.48**	-3.46**	8.45**	1.27**	0.41	-17.87	-0.75**	5.77**
RAU 1411-10	0.19	1.65*	11.64**	-4.00**	2.17**	10.93**	0.53*	7.94**
SE (±)	0.67	0.65	0.59	0.44	0.43	1.62	0.21	1.85
C.D. (T) at 5%	1.84	1.04	1.65	1.23	1.20	4.50	0.60	3.77
C.D. (T) at 1%	2.42	1.38	2.17	1.62	1.57	5.92	0.78	4.95
Correlation 'r'	-0.089	-0.085	0.579*	-0.084	0.504*	-0.032	0.249	0.067

* & ** = Significant at P = 0.05 and 0.01, respectively.

specific combining ability effects parents only non-additive gene action. The presence of non-additive genetic variance offers scope for exploitation of heterosis. Among male lines, Pusa 1040, PSRM-1-16-48-1 and RAU 1411-10 were found to be best general combiner for grain yield. Tester Gautam was the best general combiner for early flowering and maturity indicating its role in breeding early duration rice varieties.

The IR 58025A was a good general combiner for grain yield and its major components. Better gca for days to 50% flowering, days to maturity and plant height was exhibited by IR 68886A, while illustrated that it is worth while to transfer its male sterility into genetic background of elite lines having good gca for yield and its components (Table 1). Kaushik and Sharma (1988) and Ramalingam *et al.* (1993) reported higher gca variances for days to flowering and plant height.

Out of 27 hybrids, ten hybrids depicted significant positive effect for grain yield plant⁻¹. IR 68886A × Pusa 1040 showed low sca effects for days to 50% flowering and high for 1000-grain weight and grain yield plant⁻¹. IR 68897A × RAU 1411-4 showed high sca effect for number of effective tillers hill⁻¹ and 1000-grain weight. The combination IR 68886A × PSRM-1-16-48-1 exhibited high sca effects for panicle length and grain yield plant⁻¹. Manuel and Palanisamy (1989) and Dhaliwal and Sharma (1990) also reported that non-additive gene effects were predominant for yield and its components. It is evident that cross combinations which expressed high sca effects for grain yield have invariably exhibited positive sca effects for one or more yield related traits also and as such while selecting the best specific combination of yield, it would be important to give due weightage to yield related traits (Table 2 and Table 3).

Table 2. Best 10 hybrids for grain yield along with their heterosis and sca effects

Hybrid combination	Grain yield plnat ⁻¹ (g)	Standard heterosis over Saroj	Specific combining ability
IR 68886A × Pusa 1040	83.6	111.28**	41.05**
IR 58025A × RAU 1411-10	60.5	52.78**	12.72**
IR 68886A × PSRM-1-16-48-1	57.8	45.96**	18.11**
IR 58025A × Gautam	50.3	27.02**	20.45**
IR 68897A × RAU 1411-10	49.0	23.73**	14.50**
IR 68897A × RAU 1411-4	46.16	16.57**	13.83**
IR 58025A × PSRM-1-16-48-1	45.8	15.66**	-3.77
IR 58025A × Pusa 1107	44.66	12.78**	10.37**
IR 68897A × Dhanlaxmi	40.5	2.28	16.94**
IR 58025 A × RAU 1411-4	39.33	-0.68	-6.27**

** Significant at P = 0.01 level.

Table 3. Best three hybrids on the basis of heterosis, per se performance and sca effect for characters in rice

Character	Best hybrid on the basis of standard heterosis over Saroj	Best hybrid on the basis of per se performance	Best specific combiner
Days to 50% flowering (earliness)	IR 68886A × Gautam	IR 68898A × RAU 1411-4	IR 68897A × RAU 1411-10
	IR 68898A × RAU 1411-10	IR 68886A × RAU 1411-4	IR 68886A × Gautam
	IR 58025A × Prabhat	IR 58025A × Prabhat	IR 68886A × RAU 1411-4
Days to maturity (earliness)	IR 68886A × Gautam	IR 68886A × Gautam	IR 58025A × Dhanlaxmi
	IR 58025A × Gautam	IR 58025A × Gautam	IR 68897A × RAU 1411-10
	IR 68886A × Prabhat	IR 68886A × Prabhat	IR 58025A × Saroj
Plant height (dwarfness)	IR 68897A × Prabhat	IR 68897A × RAU 1411-4	IR 68886A × RAU 1411-10
	IR 68886A × Pusa 1107	IR 58025A × Dhanlaxmi	IR 68886A × Pusa 1007
	IR 68897A × Dhanlaxmi	IR 68886A × RAU 1411-10	IR 68897A × Prabhat
No. of effective tillers hill ⁻¹	IR 68897A × RAU 1411-4	IR 68897A × RAU 1411-4	IR 68897A × RAU 1411-4
	IR 68897A × Saroj	IR 68897A × Saroj	IR 68897A × Saroj
	IR 68886A × Gautam	IR 68886A × Gautam	IR 68886A × Gautam
Panicle length	IR 58025A × Pusa 1107	IR 58025A × Pusa 1107	IR 58025A × Pusa 1007
	IR 58025A × RAU 1411-10	IR 68897A × RAU 1411-10	IR 68886A × RAU 1411-4
	IR 68886A × PSRM-1-16-48-1	IR 68898A × PSRM-1-16-48-1	IR 68886A × PSRM-1-16-48-1
Sterility %	IR 68897A × Gautam	IR 68897A × Gautam	IR 68897A × Gautam
	IR 68886A × RAU 141110	IR 68898A × RAU 1411-10	IR 68886A × RAU 1411-10
	IR 58025A × Pusa 1040	IR 58025A × Pusa 1040	IR 58025A × Pusa 1040
	IR 68886A × RAU 141110	IR 68886A × RAU 1411-10	IR 68886A × Pusa 1040
1000-grain weight	IR 68886A × Pusa 1040	IR 68886A × Pusa 1040	IR 68897A × RAU 1411-4
	IR 58025A × Gautam	IR 58025A × Gautam	IR 58025A × Pusa 1007
	IR 68886A × Pusa 1040	IR 68886A × Pusa 1040	IR 68886A × Pusa 1040
Grain yield plant ⁻¹	IR 58025A × RAU 1411-10	IR 58025A × RAU 1411-10	IR 58025A × Gautam
	IR 68886A × PSRM-1-16-48-1	IR 68886A × PSRM-1-16-48-1	IR 68886A × PSRM-1-16-48-1

REFERENCES

- Arunachalam, V. 1974. The fallacy behind the use of modified line $\times$ tester design. *Indian J. Genet.*, **34** : 200-207.
- Dhaliwal, T.S. and Sharma, H.L. 1990. Combining ability and maternal effects for agronomic and grain characters in rice. *Oryza*, **27** : 122-128.
- Kaushik, R.P. and Sharma, K.D. 1988. Gene action and combining ability for yield and its component characters in rice under cold stress condition. *Oryza*, **25** : 1-9
- Kempthorne, O. 1957. An Introduction to Genetical Statistics. John Wiley and Sons, New York, USA.
- Manuel, W.W. and Palanisamy, S. 1989. Line and tester analysis of combining ability in rice. *Oryza*, **26** : 27-32.
- Ramalingam, J.; Vivekanandan, P. and Vnnia Ranjan, V. 1993. Combining ability analysis in low and early rice. *Crop Res.*, **6** : 228-233.
- Yadav, L.S.; Maurya, D.M.; Giri, S.P. and Singh, S.B. 1999. Combining ability analysis for yield and its components in hybrid rice. *Oryza*, **36** (3) : 208-210.
- Yadav, S.P. and Murty, B.R. 1966. Heterosis and combining ability of different height categories in bread wheat. *Indian J. Genet.*, **36** : 184-196.

INDEX OF DROUGHT RESISTANCE IN RELATION TO WATER RETENTION PARAMETERS IN BREAD WHEAT

S.S. DHANDA AND G.S. SETHI

*Department of Plant Breeding
CCS HAU, Hisar-125004 (Haryana)*

ABSTRACT

Out of three sets of experiments with 30 wheat genotypes, one set was evaluated under well irrigated and two sets were evaluated under drought stress conditions by developing drought stress at anthesis stage in one set and at maturity stage in other set for two years. Genotypes differed in their responses at both stages of plant growth for all characters. Significant genotype $\times$ year interaction indicated differential responses of genotypes over the years. Continued water deficit resulted in reduced mean values and variability for all the characters. The varieties WH 147, WH 147 (U) showed a combination of traits like drought resistance, water retention and grain yield, whereas C 306, Kharchia 65 and Hindi 62 showed least percentage of injury in plasma membranes and better water retention in leaves. Relative water content and excised-leaf water loss appeared to be the important characters as the varieties having better resistance also had better performance in these characters.

Key words : Drought, index, water, wheat.

Wheat is mainly grown under rainfed areas of the world where rainfall ranges from 250 to 2000 mm annually (Nagarajan *et al.* 1998). Thirty seven percent of the area in the developing countries consists of semi-arid environments in which available moisture constitute a primary constraint on wheat production. Climatic variability in these marginal environments causes large annual fluctuations in yield. Selecting wheat genotypes with better adaptation to water stress should increase the productivity of rainfed wheat.

Several strategies have been devised to overcome the problem of drought stress. In this connection, a few of the numerous drought screening tests have been identified for their use in breeding programme (Dhanda *et al.*, 1995, 1998. Several workers (Passioura, 1981; Ludlow and Muchow, 1990) have shown that a greater rooting depth is associated with improved performance under water limited conditions. Recently, assessment of water loss from excised leaves (ELWL) has shown promise for characterizing drought resistance in wheat genotypes (Clarke *et al.*, 1989; McCaig and Romagosa, 1991).

Breeding efforts for improved drought tolerance have been revolving around the exploitation of high yield potential under and irrigated drought stress conditions (Turner, 1986). Bidinger *et al.* (1987) proposed drought resistance index that is based on residual variation for categorization of drought resistant cultivars. Improvements of yield under drought stress conditions should combine a reasonable high index of drought resistance with specific plant factor which would buffer the yield against severe reduction under stress. Genetic variation for yield as well as drought resistance index is limited. However, it can be further exploited by identification of single or multiple morphological traits for drought resistance. The aim of this study was to establish the extent of genetic variation and to assess the drought tolerance among the wheat genotypes on the basis of drought resistance index and water relation parameters.

MATERIALS AND METHODS

Three sets of 30 contrasting wheat genotypes was grown under drought stress and irrigated conditions at the HPKV, Palampur, H.P. One

set of 30 genotypes was grown under irrigated condition and remaining two sets were grown under drought stress conditions for developing drought stress at anthesis and maturity stages of plant growth.

Drought stress at anthesis was created by withholding irrigation at 30 days after sowing and maturity by withholding irrigations at 70 days after sowing. Plot size for both environments consisted of 2 lines of 3m long with plant to plant spacing of 10 cm. For recording observations for excised-leaf water loss (ELWL), relative water content (RWC) the plants were observed for temporary wilting in the evening and only these plants which were not recovered during night were selected for recording observations on the following day in the first set during 65-70 days after sowing. In second set the data for days to heading, maturity and grain yield was recorded during 95-105 days after sowing.

Data for RWC and ELWL was observed from flag leaf and, two fully expended preceding leaves in that order. In order to avoid any complication due to variation in level of mid-day water deficit, the data for both the characters were recorded from predawn measurements. For ELWL the leaves were weighed at three stages, viz., immediately after sampling (Fresh weight), drying in an incubator at 28°C at 50 percent R.H. for 6hr., and then oven drying for 24h at 70°C. ELWL was then calculated from the following formula :

$$\text{ELWL} = [\text{Fresh weight} - \text{Weight after 6h}] / (\text{Fresh weight} - \text{Dry weight}) \times 100$$

The samples for RWC were also weighed immediately as fresh weight (FW), then sliced into 2 cm sections and floated on distilled water for 4h. The turgid leaf discs were then rapidly blotted to remove surface water and weighed to obtain turgid weight (TW). The leaf discs were dried in the oven at 60°C for 24 h and then dry weight (DW) obtained. The RWC was calculated by the formula given by Barrs (1968).

Drought resistance for individual genotype was computed by the formula given by Bidinger *et al.* (1987). Positive value of DRI for each

genotype denoted drought tolerance, whereas negative values denoted drought susceptibility.

RESULTS AND DISCUSSION

Magnitude of differences in environments and genotypes was sufficient to provide a scope of selected these traits for improvements of drought tolerance of wheat genotypes. The interaction of genotype $\times$ year was also significant for all characters indicated that different varieties have differential response over the years. Mean performance of all genotypes is given in Table 1. The genotypes WH 147(U), Kharchia 65, C 306, WL 1562, VL 421 and HPW 2 showed significantly minimum water loss and better water retention in E2. This suggested that these varieties may be able to give good results by avoiding drought through lesser water loss and retaining more water and maintaining water balance in leaves. Genotypic variation for excised-leaf water loss and relative water content at anthesis stage in wheat has also been reported by various workers (Blum, 1988; McCaig and Romagosa, 1991).

The general observation that breeding and selections for high yield under optimal conditions also results in marked improvements under less optimal conditions. However, this may be true only for WH 147(U) that is showing combination of higher yield under both conditions. This variety is an improved strain of WH 147 which had a combination of high yield potential with drought related traits and early days to heading (Nagarajan *et al.*, 1998) which can buffer grain yield against severe yield reductions under drought stress performance of majority of the genotypes under irrigated and drought stress environments indicated the traits which contributed to high yield under irrigated may be different than those of high yield under drought stress. Acevedo *et al.*, 1991 also suggested that the different type of approaches for improvements of barley under rainfed that under irrigated conditions. The varieties C 306 (7.0*) and Kharchia 65 (5.5*) had significantly higher grain yield under drought stress only. This indicated that the grain yield in these varieties may be due to the contribution of drought tolerance traits than

Table 1. Mean performance of 30 wheat genotypes for various characters at anthesis stage of plant growth

Genotype	Excised-leaf water loss	Relative water content	DRI
WH 147	71.6*	68.0*	1.7*
WH147(U)	68.1*	66.0*	2.0*
Lok 1	68.9	56.7	0.3
Lok 1 (U)	72.3	65.0*	0.9
WH 157	77.9	64.1*	0.5
Kharchia 65	62.3*	63.9*	2.0*
HW2001	81.1	42.2	-1.8*
CPAN 1992	82.2	45.1	-0.7
C306	63.3*	75.9*	3.9*
K68	81.1	41.0	-2.1*
WH331	82.2	41.9	-0.1
WH533	63.3*	56.3	-1.4*
Hindi 62	81.3	43.9	0.2
PBW65	73.0	53.1	-0.6
WL410	67.9*	43.1	-0.9
WL1562	64.0*	58.1*	0.1
Kundan	80.1	56.9	0.2
HPD(131)	79.1	62.1	0.1
VL421	67.9*	59.8*	0.7
HD2329	68.9	41.9	-0.8
HD2329(U)	79.2	43.1	-0.2
HPW42	67.0*	57.9*	-0.5
HS295	81.0	35.3	-1.1
HPW56	80.0	55.7	0.4
CPAN3004	83.1	42.7	-1.0
HPW65	65.0*	55.7	-1.2*
RL6	67.2*	42.9	-0.2
RL7	65.9	47.9	0.1
RL68	61.0*	36.0	-1.0
RL84	71.1	40.0	-0.1
Mean	72.9	51.9	0.0
LSD ^a	4.5	5.3	1.2
SE(m)b	1.9		

LSD^a : For comparison of mean values of two entries in the same column; SE(m)b : for comparison of overall mean of different column.

the yield potential. Under drought stress conditions, plant earliness is an important factor in sustaining yield. The conventions assume that an advantage of earliness as an escape mechanism when crop is subjected to pre and post-heading terminal stress (Blum, 1989).

DRI values indicated that the variety C 306 (3.9*) was the most tolerant followed by Kharchia 65 (2.6*). These varieties also performed better for other drought related traits except for earliness indicating their tolerance and/or avoidance to drought stress (Bansal and Sinha, 1991; Dhanda and Sethi, 1996). High DRI values

in WH 147(U) (2.0*) and WH 147 (1.7*) were not also be due to their escape from severe drought but due to the contribution of drought related traits, as the effect of earliness has been removed while calculated DRI values.

Thus, yield alone cannot be used as selection criteria. Therefore, improvements of yield under drought stress should combine a reasonably high yield potential with a specific plant factor which would buffer yield against a severe reduction under stress (Blum, 1989). Days to heading had fewer relations with the characters studied. This may either due to limited variation in this character or large environmental variation. In addition, non-significant correlation

of days to heading with drought resistance indicates the independence of drought resistance index from this intervening factor. The association of drought resistance index with other characters indicated that the drought resistant plants, in general, had lesser water loss and better water retention capacity, lesser injury in plasma membrane and higher yield in this set of material.

Acknowledgments

The financial assistance given to the first author in the form of senior research fellowship by the Council of Scientific and Industrial Research, New Delhi, towards his Ph.D. thesis is duly acknowledged.

REFERENCES

- Acevedo, E; Craufurd, P. Q.; Austin, R.B. and Perez-macro, P. 1991. Traits associated with high yield in barley in low rainfed environments. *J. Agric. Sci. Cambridge*, **116** : 23-26.
- Bansal, K.C. and Sinha, S.K. 1999. Assessment of drought resistance in 20 accessions of *Triticum aestivum* and related species I. Total dry matter and grain yield stability. *Euphytica*, **56** : 7-14.
- Barrs, H.D. 1968. Determination of water deficits in plant tissues. p 235-368. In: T.T. Kozlovski (Ed.) Water deficits and plant growth. Vol. I. Academic Press, New Delhi.
- Bidinger, F.R., Mahalaxmi, B. and Rao, G.D.P. 1987. Assessment of drought resistance in pearl millet. Estimation of genotypic response to stress. *Aust. J. Agric. Res.*, **38** : 49-59.
- Blum, A. 1988. Plant breeding for stress environments. CRC Press USA.
- Calrke, J.M. 1987. Use of physiological and morphological traits in breeding.
- Clarke, J.M., Romagosa, I., Jana S., Srivastava, J.P. and Mc Caig, T.N. 1989. Relationship of excised-leaf water loss rate and yield of durum wheat in diverse environments. *Can J. Plant Sci.*, **69** : 1075-1081.
- Dhanda, S.S. and Sethi, G.S. 1996. Genetics and inter-relationships of grain yield and its related traits in bread wheat under irrigated and rainfed conditions. *Wheat Information Service*, **83** : 19-27.
- Dhanda, S.S. Behl, R.K. and Elbassam 1995. Breeding wheat genotypes for water deficit environments. *Landbauforschung Volkenrode*, **45** : 159-167.
- Dhanda, S.S., Sethi, G.s. and Behl, R.K. 1998. Excised leaf water loss as a simple selection criterion for drought resistance in wheat. *Der Tropenlandwirt*, **1** : 3-8.
- Ludlow, M.M. and Muchow, R.C. 1990. A critical evaluation of traits for improving crop yields in water limited environments. *Adv. Agron.*, **42** : 107-153.
- Mc Caig, T.N. and Ramagosa, I. 1991. Water status measurement of excised leaves : Position and age effects. *Crop Sci.*, **31** : 1583-1588.
- Nagarajan, S., Singh, G. and Tyagi, B.S. 1998. Wheat : Research Needs Beyond 2000 A.D. New Delhi ; Narosa Publishing House.
- Passioura, J.B. 1981. The interaction between physiology and breeding wheat. In : Wheat Science today and tomorrow. Ed. Evans L.T. and Steven, P.J., John Wiley and Sons, USA. 191-211.
- Turner, N.C. 1986. Crop water deficits : A decade of progress. *Adv. Agron.*, **39** : 1 - 51.

CELLULASE ACTIVITIES AND ITS CORRELATION TO YIELD IN EARLY AND LATE STRAIN OF *PLEUROTUS* SPP.

MADHURENDRA, N. PRASAD AND S.G. SHARMA*

Department of Biochemistry
Faculty of Basic Science & Humanities
Rajendra Agricultural University, Pusa, Samastipur - 848125
*Department of Biochemistry, CRRI, Cuttack, Orissa

ABSTRACT

Pleurotus djamor R₂₂ (First flush, 12 days) and *Pleurotus pulmonarius* WC 537 (first flush, 21 days) have the capacity to grow on paddy straw and produce fruit bodies during the solid substrate fermentation. Both produced the complete cellulase complex consisting of exo- β -a, 4-Glucanase, endo- β -1, 4-glucanase and β -1, 4-glucosidase activities which could be detected in culture filtrates, cell free extracts and the particulate fractions as well. *P. pulmonarius* WC 537, which has higher yield and longer crop duration, was found to exhibit a consistently higher cellulase activity as compared to *P. djamor* R₂₂ throughout the present study indicating a possible correlation between yield and cellulase activity.

Key words : Cellulase, *Pleurotus* spp., activity.

A number of higher fungi basidiomycetes are known to possess high lignin degrading activity and thus have been employed to delignify crop residues. The degradation of ligno cellulosic residues by these fungi is brought about by the action of extra cellular enzyme such as ligninases, cellulases and xylanases (hemicelluloses) and depends on the synergistic action of these enzymes. These enzymes are characteristically produced by higher Fungi particularly the wood degrading basidiomycetes (Boominathan and Reddy 1992, Markham and Bazin 1991). The synergistic action of cellulase enzyme produced during the growth of mushroom in solid substrate fermentation, hydrolyses cellulose, a major constituent of paddy straw to glucose (Montene Court *et al.* (1985). Hence there is close relationship between degree of degradation of cellulose and yield of mushroom. Phutela *et al.* (1996) indicated that cellulase production capacity might be a determinant of yield potential of *volvariella* spp. Taking this observation into consideration we selected two species of *Pleurotus* that differed substantially in the crop duration the ability to produce *Pleurotus* spp. on paddy straw. The distribution of the enzymes of the cellulase com-

plex in culture filtrate (CF), Cell free extract (CFE) and the particulate fraction (PI) was also studied.

MATERIALS AND METHODS

What based spawn - culture of *Pleurotus djamor* R₂₂ and *Pleurotus pulmonarius* WC 537 were obtained from the Rajendra Agricultural University, Pusa, Bihar. The former gives first flush within 12 days and produces attractive, pink-colored fruiting bodies. The two species were grown on chopped paddy straw as described by (Sharma and Singh, 1993). The samples of inoculated paddy straw were collected at 7 days intervals till 21 days.

Three fraction, namely Culture Filtrate (CF), Cell Free Extract (CFE) and the Particulate Fraction (PF) were prepared from the inoculated substrate. The activities of enzymes of the cellulase complex i.e. exo-glucanase, endo-glucanase and β -Glucosidase were assayed by the method of Bostawade *et al.* (1977) and sugar estimation was done by the method of Lowry *et al.* (1951) using FolinCiocalteu reagent. One unit of exo-or-endo- β -1, 4 glucanase activity was defined as the amount of enzyme that caused liberation of 10 μ g of glucose under the assay

conditions and was expressed in terms of specific activity (unit mg^{-1} protein). One unit of β -glucosidase activity was the amount of enzyme that caused liberation of 10 μg p-nitrophenol under the assay conditions. To prepare the various fractions 5 g of the inoculated substrate was shaken vigorously with 20 ml of ice-cold-0.05 M acetate buffer, pH 4.8 containing 1% (w/v) polyvinyl polypyrrolidone for 30 minutes and filtered through muslin cloth. The filtrate was centrifuged at $10,000 \times g$ at 40°C for 10 minutes. The supernatant served as the culture filtrate (CF). The residue was washed with buffer to remove any sticking enzyme and later thoroughly triturated with a little buffer in a mortar with a pestle and centrifuged as before. The supernatant served as the cell free extract (CFE). The pellet was mixed well with 10 ml of buffer and centrifuged to wash free of any sticking enzyme. The residue so obtained was swirled with 10 ml of the buffer and served as the particulate fraction (PF). Fruiting bodies were collected after first picking. The data represent mean of four replication.

RESULTS AND DISCUSSION

The specific activities of the cellulase

complex as observed in the CF, CFE and the PF are presented in Tables 1, 2 and 3. All the three activities of the cellulase system i.e. exo-and-endo- β -1,4 glucanase and β -1,4-glucosidase were present in each fraction prepared from the inoculated substrate. Activity of each enzyme in various fractions was highest on the 7th day. Higher activity on the 7th day are in the agreement of the work of Choudhary *et al.* (1994). None of the enzyme was detectable on zero day. The highest activity of each enzyme was observed in the CF followed by that in CFE. It was only in case of β -glucosidase that the enzyme activities in CF and CFE were comparable while that in the PF was the lowest.

From the perusal of data in Table 1, 2 and 3, it is obvious that higher specific activity of the cellulase complex enzyme were exhibited by *Pleurotus pulmonarius* WC 537 as compared to *Pleurotus djamor* R22 which exhibited lesser activities. The cellulase activity is known to increase and it is accompanied by cellulase activity remained quite high upto the 14th day in both straw of *Pleurotus* spp. There after these enzymes started decreasing as these might have been utilized by the two fungi to degrade cellulose

Table 1. Changes in exo- β -1,4-glucanase activity in various fractions prepared from paddy straw inoculated with *P. djamor* R₂₂ (T₁) and *P. pulmonarius* WC 537 (T₂)

Days after inoculation	Exo- β -1,4-glucanase (unit/mg) protein)					
	T ₁			T ₂		
	CF	CFE	PF	CF	CFE	PF
0	-	-	-	-	-	-
7	40	38	15	47	35	18
14	33	22	11	35	25	15
21	4	2	2	7	5	5

Table 2. Changes in exo- β -1,4-glucanase activity in various fractions prepared from paddy straw inoculated with *P. djamor* R₂₂ (T₁) and *P. pulmonarius* WC 537 (T₂)

Days after inoculation	Endo- β -1,4-glucanase (unit/mg) protein)					
	T ₁			T ₂		
	CF	CFE	PF	CF	CFE	PF
0	-	-	-	-	-	-
7	51	45	16	54	45	18
14	41	32	12	41	35	15
21	11	8	7	13	9	9

and utilize the carbon atom derived from the breakdown of glucose to synthesize amino acid which are assembled to form protein of the fruit body. The crystalline regions of cellulose is attacked by exo-glucanase, the resulting free ends are then attacked by endo-glucanase followed by β -glucosidase catalyzed hydrolysis. The activity of exo-glucanase, an important component of the cellulase complex, is expected to have caused initial disordering of the native cellulose microfibrils of paddy straw while endo-glucanase is known to degrade amorphous

region of the cellulosic substrates.

The data presented in Tables 1, 2 and 3 also indicated that there was rapid development of activities of cellulose complex enzymes initially which started decreasing after first week in all three fractions. Similar results have been reported by Platt *et al.* (1984). From the data in Table 4 it is clear that *P. pulmonarius* WC 537 is far more efficient at producing fruiting bodies than *P. djamora* R₂₂. So it is concluded that there is possible correlation between yield of fruit bodies and cellulase activity.

Table 3. Changes in β -glucosidase activity in various fractions prepared from paddy straw inoculated with *P. djamora* R₂₂ (T₁) and *P. pulmonarius* WC 537 (T₂)

Days after inoculation	β -glucanase (unit/mg protein)					
	T ₁			T ₂		
	CF	CFE	PF	CF	CFE	PF
0	-	-	-	-	-	-
7	32	29	16	33	25	18
14	20	18	12	22	12	16
21	3	2	9	8	5	11

Table 4. Yield of *Pleurotus* spp.

Dry wt. of paddy straw (g)	Fresh wt. of mushroom (g)	
	<i>P. djamora</i>	<i>P. pulmonarius</i>
400	527	673
400	556	677
400	520	688
400	542	694

REFERENCES

- Bostawde, K.B., Deshpande, V.V., Jogle, Kar, A.K., Lakshmikanthan, B.C., Mishra, C., Phasalkar, S.B. Rao, M., Seeta, R., Srinivasan, M.C. and Jaggannathan, V. 1977. Cellulolytic enzymes of *Penicillium* strain. In T.K. Ghose (ed.) *Bioconversion of Cellulosic substances into energy chemicals and microbial protein*. Indian Institute of Technology, New Delhi pp. 143-151.
- Lowery, O.H., Rosebrough, N.J., Forr, A.L. and Rainfall, R.J. 1951. Protein measurement with the folin phenol reagent, *J. Biol. Chem.*, **193** : 265-275.
- Miller, G.L. 1959. Use of dinitrosalicylic acid reagent for the determination of reducing microbial enzyme. *Comprehensive Biotechnology*, **4** : 329-361.
- Montene Court, B.S., Carrol, J.O. and Lenzilatta, R.P. 1985. Assay of industrial microbial enzyme. *Comprehensive Biotechnology*, **4** : 329-361.
- Platt, M., W., Haider, Y. and Chet, I. 1984. Fungal activities involved in lignocellulose degradation by *Pleurotus* *Appl. Microbial Biotechnol.*, **20** : 150-154.
- Sharma, S.G. and Singh, V.K. 1997. *J. Mushroom Res.* **6** : 99-100.
- Choudhary, L.C., Singh, R. and Kamara, D.N. 1994. Biodelignification of sugarcane bagasse by *Pleurotus florida* and *Pleurotus cornucopine*. *Indian J. Microbiol.*, **34** : 55-57.

AAMI ANALYSIS FOR GRAIN YIELD STABILITY OF MAIZE (ZEA MAYS L.) HYBRIDS

D.M. REDDY*, V.P. AHUJA AND B.K. MUKHERJEE

Division of Genetics
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

AAMI (Additive Main Multiplicative Interaction) analysis was carried out to maize yield trials conducted with forty-five hybrids over four environments (years/locations) to identify suitable and stable hybrids. Grain yield data were subjected to the AMMI analysis. Analysis revealed significant $G \times E$ interaction which could be attributed to differential ranking of the genotypes across the environments. The $G \times E$ interaction was further partitioned into PCA axes, of which the first PCA axis captured 53.35% to the total $G \times E$ variance. Perusal of the biplot analysis indicated that six hybrids viz., H26, H17, H2, H3, H21 and H38 were identified as having general adaptability with high mean yields and PCA scores nearer to zero. Similarly among the environments DEL95 with PCA score nearer to zero was found ideal for stable performance of the hybrids.

Key words : Maize, AAMI, analysis, Grain yield, biplot, stability.

An understanding of genotype $\times$ environment interaction is fundamental to any crop improvement programmes, where the performance of a cultivar is judged based on the yield trials conducted over locations/year or location and year combinations. These yield trials frequently have both significant main effects and a significant genotype $\times$ environment (GE) interactions. Traditional statistical analysis are not always effective with this data structure interactions. Traditional statistical analysis are not always effective with this data structure interactions. Traditional statistical analysis are not always effective with this data structure (Zobel *et al.* 1998, Crossa *et al.* 1991, Sharma *et al.* 1998 and Shinde *et al.* 2002). The usual ANOVA, having a merely additive model, identifies the GE interaction as a source but does not analyze it, on the other hand PCA (Principal component analysis) is a multiplicative model and hence contain no sources for additive genotype or environment main effects, and the most widely used LR (Linear regression) analysis is able to effectively analyse interaction terms only where the pattern fits a specific regression model.

*Present address : Pulses Section, Regional Agricultural Research Station, Lam Farm, Guntur-522034, A.P.

Resizing these theoretical and applied problems in estimating and comparing the $G \times E$ interaction, different statistical models have been developed, of which AMMI (Additive main and Multiplicative interaction) model is worth to be considered. AMMI offers a more appropriate first statistical analysis of yield trials that may have a genotype $\times$ environment interaction, since ANOVA, PCA and LR are sub cases of the more complete AMMI model. The effectiveness of this AMMI model has been applied to maize data and detailed discussions were also made by Crossa *et al.* (1990). Hence the present study was undertaken to use additive main and multiplicative model (AMMI) to determine the nature and magnitude of $G \times E$ interaction effects in order to compare the newly generated maize hybrids developed in maize research project at Indian Agricultural Research Institute, New Delhi and the predict high yielding and stable ones before recommending to diverse productive environments.

MATERIALS AND METHODS

Forty five maize hybrids generated through 10×10 diallel mating design were grown using randomized complete block design with three replications at the Indian Agricultural Research

Institute, New Delhi and HAU Regional Agricultural Research Station, Uchani, Karnal for two years (Kharif 95 and Kharif 96) consecutively, thus making total four environments. From now onwards the four environments are represented as Del95, Del 96, Kar95 and Kar96. At each environment, experimental plot consisted of two rows of 5 m length each with a row to row distance of 75cm and plant to plant distance of 25cm. Planting and harvesting was done by hand at each location. All plots were over planted and thinned to desired stands. Yield data (g/plant) were recorded by averaging five individual plants data for each hybrid in each replication at all the four locations and used for the AMMI statistical analysis. Prior to AMMI analysis, analysis of variance was performed for grain yield per plant (g) and then pooled over environment after testing of homogeneity of error variances. The appropriate statistical model (fixed effects) for AMMI is as follows :

$$Y_{ge} = \mu + \alpha_g + \beta_e + \sum_{n=1}^N \lambda_n \zeta_{gn} \eta_{en} + \theta_{ge}$$

Where Y_{ge} is the yield of genotype, g , in environment e ; μ is the grand mean; α_g is the genotype mean deviation; β_e is the environment mean deviation; λ_n is the eigenvalue of the PCA axis n ; ζ_{gn} and η_{en} are the genotype and environment PCA scores for the PCA axis n ; N is the number of PCA axes retained in the model; and θ_{ge} is the residual. The $G \times E$ interaction sum of squares was subdivided in to PCA axes. The F tests to determine the significance of the PCA MS, degrees of freedom were calculated by the simple method of Gollob (1968). i.e. $df = G+E-1-2n$, where G is the genotypes; E is the environments and N is the PCA axes.

RESULTS AND DISCUSSION

The perusal of mean yield data for 45 hybrids over four environments (Table 1) clearly demonstrated the varied performance of the hybrids studied. The AMMI analysis of variance revealed that mean sum of squares for genotypes, environments and $G \times E$ interaction were found significant, which indicates that the performance

of genotypes was differential over the environments under consideration. Out of the total treatment variation (Trial SS), the proportion of variance due to differences in environments was maximum (45.52%) followed by the variance due to $G \times E$ interaction (33.0%) and the variance due to genotypes (21.46%).

The $G \times E$ interaction was further partitioned into two PCA axis, of which the first PCA axis captured 53.35% followed by the second PCA axis with 27.63% and the residual with 19.02% of the interactions. The mean sum of squares for all these axis were found significant and the complete AMMI model contained total 100% of the SS of the interactions. These values indicate that AMMI summarized these data very effectively. However, the present analysis revealed the presence of a complex and multinational variation in genotype $\times$ environment data as all the PCA axes were demonstrated to be highly significant. The AMMI models with many PCA axes are expected to involve rather noise than the highly complex interactions among the genotypes and environments. Further, if the AMMI model includes more than one PCA axes, assessment and presentations of genetic stability become complex (Crossa *et al.* 1991), Sharma *et al.* 1998 and Sinde *et al.* 2002). Hence in the present AMMI model first IPCA axis was adopted for further study.

The results of the AMMI analysis can also be represented with the help of biplot presentation as shown in Fig. 1. The main effects (genotype means and environment means) are shown along the abscissa (X-axis) and the ordinate (Y-axis) represents the first PCA. The mean performance and PCAI scores for both the genotype and environments used to construct the biplot are presented in Table 2. In Fig. 1, for any genotype-environment combination, the main effect equals the genotype mean plus the environment mean minus the grand mean, and the interaction is the genotype PCA score times the environment PA score (Zobel *et al.*, 1998). For example, hybrid no : 42 grown in KAR95 has a main effect of $90.19 + 86.17 - 104.40 = 71.96$ g/plant and an interaction effect of $2.95 \times 3.56 =$

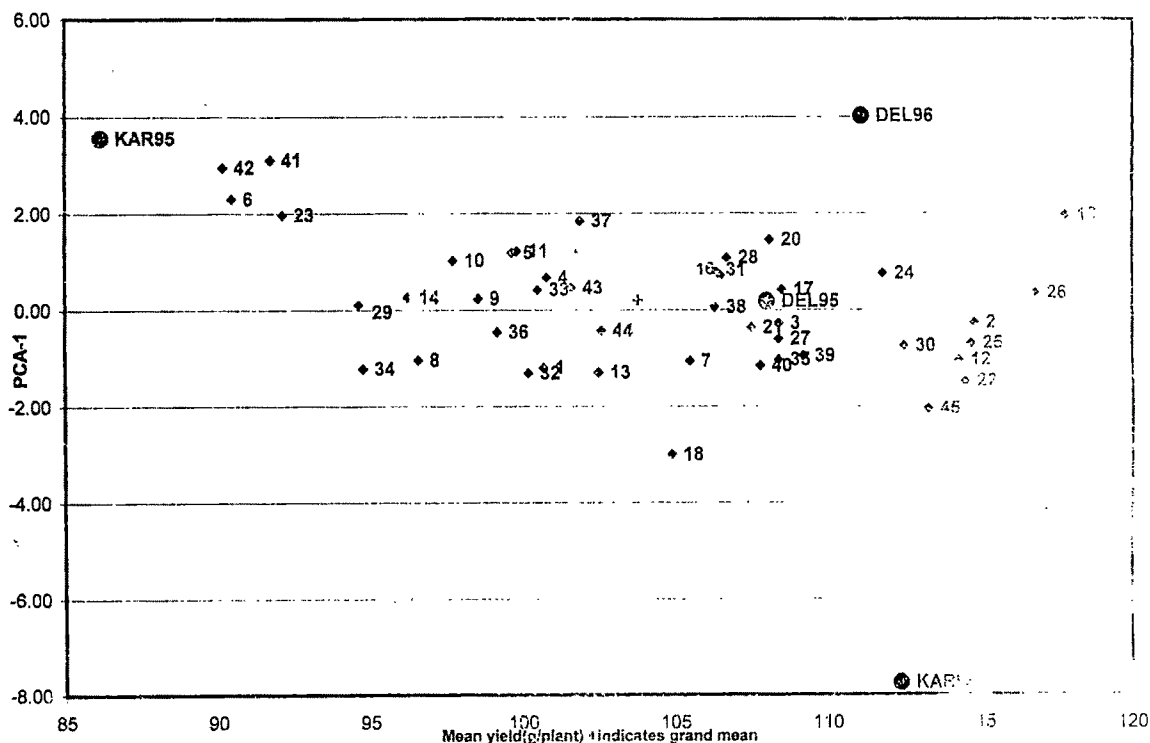


Fig. 1. Biplot of the AMMI-1 model for a maize hybrids yield trial with 45 hybrids and 4 environments

10.50 g/plant. Therefore, the AMMI model gives a yield estimation of 82.46 g/plant for hybrid no : 42 in Kar95 location, which is nearer to the actual yield of 80.0 g/plant. Where as, by contrast the additive ANOVA yield estimation of 71.96 g/plant gives a poor fit. The example clearly justifies the greater accuracy of AMMI model.

The interpretation of the biplot presentation (Fig. 1), where both main effects and interaction component are clearly depicted, is that if a genotype or an environment has a PCA score of nearly "0", it has small interaction effects and when a genotype and an environment have the same sign on the PCA axis, their interaction is positive, if different their interactions negative (Zobel *et al.*, 1998). Therefore, the genotype and environment that appear on almost perpendicular line have similar means where as those falling almost of horizontal line have similar interaction pattern. Also, the genotypes which are greater than the grand mean and the PCA score nearly zero, are considered as generally adaptable to all the environments. Where as, the genotypes

with high mean and large value of PCA scores are considered as having specific adaptability to the specific environments.

According to the biplot assay of the present analysis, six hybrids viz., H26, H3, H17, H2, H21 and H38 showed higher mean yield than grand mean (marked with '+' sign in Fig. 1) values with PCA score nearer to zero. Among these hybrids H26 also recorded for second highest yield, based on the pooled data over environments. Hence, these hybrids can be considered as having high yield with general adaptability. Where as the hybrids viz., H19, H24, H20, H28, H16 and H31 showed high mean yield than grand mean and high interaction effects with positive PCA scores were found specially adopted to Del96. Regarding the environments, the biplot assay showed much variability among the environments. The environment DEL 95 had favorable condition for most of the hybrids with PCA score near zero indicating all the genotypes are expected to be fairly stable. However, the environments KAR95 and KAR96 had shown

Table 1. Yield of fortyfive hybrids grown in four environments (site-years) and values for the AMMI model, namely the means and the first PCA from analysis of the interaction

Code	Hybrid	Del95	Kar95	Del96	KAR96	Mean	First PCA
H1	TCA21×FSA17	99.53	80.80	103.20	119.30	100.70	-1.19
H2	TCA21×IPA3	124.60	96.03	115.80	122.80	114.80	-0.26
H3	TCA21×IPA2	107.20	79.23	126.80	120.40	108.40	-0.27
H4	TCA21×SC7	111.50	90.20	100.50	101.20	100.80	0.67
H5	TCA21×IPA3	112.80	78.97	111.20	95.70	99.66	1.18
H6	TCA21×IPA2	94.40	76.27	110.40	80.85	90.48	2.30
H7	TCA21×IPA2	111.70	89.63	100.20	120.50	105.50	-1.05
H8	TCA21×IPA8	100.80	69.10	104.00	112.50	96.60	-1.03
H9	TCA21×CM11	113.70	82.43	97.20	100.90	98.56	0.23
H10	FSA17×IPA3	101.10	84.87	107.10	97.89	97.74	1.02
H11	FSA17×IPA2	93.10	95.53	109.20	101.50	99.83	1.21
H12	FSA17×SC7	114.80	101.20	110.20	130.90	114.30	-1.03
H13	FSA17×IPA3	122.10	69.63	102.50	115.50	102.50	-1.29
H14	FSA17×IPA2	95.23	72.87	112.90	103.90	96.25	0.26
H15	FSA17×IPA2	121.30	75.77	105.90	148.00	112.70	-3.72
H16	FSA17×IPA8	107.70	92.60	115.80	109.70	106.50	0.70
H17	FSA17×CM11	110.10	78.77	130.70	114.40	108.50	0.42
H18	IPA3×IPA22	102.40	78.53	100.80	137.80	104.90	-3.00
H19	IPA3×SC7	127.50	101.30	133.50	108.90	117.80	1.96
H20	IPA3×IPA34	120.00	87.47	122.40	102.60	108.10	1.44
H21	IPA3×IPA29	90.43	72.60	122.20	124.80	107.50	-0.36
H22	IPA3×IPA21	113.10	82.20	126.90	135.80	114.50	-1.48
H23	IPA3×IPA8	94.93	81.93	106.50	85.23	92.15	1.97
H24	IPA3×CM17	127.30	99.20	110.70	110.00	111.80	0.75
H25	IPA22×SC7	120.80	89.63	121.00	127.30	114.70	-0.69
H26	IPA22×IPA3	132.00	102.90	114.00	118.20	116.80	0.34
H27	IPA22×IPA2	113.90	97.63	102.00	119.90	108.40	-0.59
H28	IPA22×IPA2	98.17	88.60	129.60	110.60	106.70	1.08
H29	IPA22×IPA8	95.50	83.43	97.20	102.40	94.64	0.11
H30	IPA22×CM11	130.70	89.27	108.60	121.50	112.50	-0.74
H31	SC7×IPA34	96.00	90.67	126.00	112.50	106.30	0.82
H32	SC7×IPA29	96.13	89.07	95.40	120.30	100.20	-1.31
H33	SC7×IPA21	103.70	85.10	107.70	105.30	100.50	0.41
H34	SC7×IPA8	100.50	73.3	93.60	111.40	94.79	-1.22
H35	SC7×CM117	106.10	100.00	101.80	125.70	108.40	-1.03
H36	IPA34×IPA2	94.70	85.20	103.80	113.00	99.18	-0.45
H37	IPA34×IPA2	110.20	91.53	111.60	94.05	101.80	1.84
H38	IPA34×IPA8	120.00	86.53	108.00	110.50	106.30	0.06
H39	IPA34×CM11	114.70	84.80	113.40	124.00	109.20	-0.95
H40	IPA 29×IPA2	105.10	90.47	109.20	126.60	107.80	-1.15
H41	IPA 29×IPA8	94.20	93.70	103.20	75.90	91.75	3.10
H42	IPA 29×CM11	90.17	80.00	113.80	76.73	90.19	2.95
H43	IPA 21×IPA8	104.00	7.40	118.20	106.70	101.60	0.46
H44	IPA 21×CM11	94.93	79.77	118.20	117.70	102.60	-0.42
H45	IPA 8×CM117	119.20	80.93	116.40	136.50	113.30	-2.05
	Site Mean	108.00	86.17	111.10	112.40	104.40	
	First PCA	0.18	3.56	4.02	-7.75		

totally reversible interaction effects and main effects and hence ranking in these environments are likely to be quite variable. In contrast the environment DEL96 had excellent potential for yield levels with positive interaction effects, and most suitable for specially adapted hybrids. Crossa *et al.* (1990) and Sharma *et al.*, (1998) and Shinde *et al.* (2002) have also found that AMMI analysis significantly improved the probability of selection of the best genotypes than the simple

ANOVA.

In conclusion, in the present analysis the over all ranking of the genotypes based on the mean and by AMMI have great discrepancies and therefore selections based on the mean alone will not be precise. Hence the present analysis supports the usefulness of the AMMI model since this model not only analyse $G \times E$ interaction but also patternise it.

REFERENCES

- Crossa J., Fox P.N., Pfeiffer W.K., Rajaram S. and Gauch H.G. 1991. *Theor. Appl. Genet.*, **81** : 27-37.
- Crossa, J., Gauch, H.G. Jr. and Zobel, R.W. 1990. *Crop Sci.*, **30** : 493-500.
- Gollob H.F. 1968. *Psychometrika*, **33** : 73-115.
- Kempton, R.A. 1984. *J. Agric. Sci. (Camb.)*, **103** : 123-135.
- Sharma, P.K., Gupta P.K. and Govila, O.P. 1998. *Indian J. Genet.*, **58** : 183-192.
- Shinde G.C., Bhingarde, M.N., Khairnar and Mehetre, S.S. 2002. *Indian J. Genet.*, **62** : 215-217.
- Zobel R.W., Wright M.J. and Gauch H.G. Jr. 1998. *Agron. J.*, **80** : 388-393.

STUDIES ON VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN POMEGRANATE (*PUNICA GRANATUM* L.) FOR YIELD AND ITS CONTRIBUTING CHARACTERS

K.K. MEENA*, ROOM SINGH AND S.K. SINGH

*Division of Fruits and Horticultural Technology
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Genetic variability, heritability and genetic advance were studied in a collection of 24 pomegranate genotypes. Considerable genetic variability for yield and its component characters were observed. High heritability in association with high genetic advance observed for dormancy duration, maturity duration, number of fruits per plant, flowering duration and yield, indicating additive gene effects and emphasized the effectiveness of selection for these traits to improve economic yield in pomegranate.

Key words : Pomegranate, yield, heritability, genetic advance.

Pomegranate is an important fruit crop among fruits grown in arid and semi-arid conditions of India. Its cultivation is spread all over the country due to hardy nature, high yield with low maintenance cost and good keeping quality (Khodade *et al.*, 1990). This fruit crop is also tolerant to salinity as well as saline irrigation water to some extent. The critical assessment of the nature and magnitude of the variability to any breeding programme. The efficiency of selection and development of improved varieties solely depends on the nature and extent of variability expressed for yield and related characters in the gene pool. Hence, an attempt was made to assess the available variability in pomegranate by partitioning of overall variability into its heritable and non-heritable components and genetic parameters like; phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and expected genetic advance so as to help in developing superior genotypes.

MATERIALS AND METHODS

Twenty four indigenous and exotic genotypes of pomegranate were taken for the present study. The experiment was laid out in a

randomized block design with three replication at the Experimental Orchard of Division of Fruits and Horticultural Technological, IARI, New Delhi during the ambe bahar (February - March) season of 1999 to 2001. Three plants were maintained in each replication with a spacing of 5 m × 5m between rows and plants, respectively. Cultural practices including need based plant protection measures were followed as per the recommendation (Malhotra *et al.*, 1983). The data were recorded on three plants randomly from each genotype in each replication for 8 characters viz., height of the plant, each-west and North-South plant spread, duration of dormancy, flowering and maturity, number of fruits and yield per plant. The mean values obtained were used for estimating analysis of variance phenotypic and genotypic coefficient of variation heritability in broad sense and expected genetic advance as per standard procedures.

RESULTS AND DISCUSSION

The analysis of variance for 8 quantitative characters revealed that mean squares were highly significant for all the characters indicating enough variability for all the traits (Table 1). However, absolute variability in different characters does not permit in deciding as to which characters is showing the highest degree of variability. Therefore, estimation of

*Present address : Near Juhi Lal Temple, Tonk Road, Durgapura, Jaipur-302018 (Rajasthan).

Table 1. Analysis of variance for 8 characters in some pomegranate genotypes

Characters	Source of variation/ Mean square		
	Replication	Treatment	Error
d.f.	2	23	46
Plant height (cm)	0.010	0.193*	0.025
East-West plant spread (m)	0.0004	0.258*	0.017
North-South plant spread (m)	0.005	0.225*	0.019
Dormancy duration (days)	0.043	3159.51*	1.25
Flowering duration (days)	3.87	139.28*	2.22
Duration from fruit set of maturity (days)	1.50	291.21*	2.54
Number of fruits per plant	5.18	297.24*	4.25
Fruit yield (kg/plant)	0.492	9.38*	0.23

*Significant at 1% level.

phenotypic and genotypic coefficient of variations become necessary. In the present investigation all the characters except, plant height and N-S plant spread showed narrow differences between the values of PCV and GCV (Table 2), implying variability due to genetic constitution. The GCV values were high for duration of dormancy, number of fruits per plant, flowering duration and yield per plant (Table 2). These results indicated that high magnitude of genetic variability existed for the above traits, offering a good opportunity for improvement through selection. This is in consonance with the findings of (Rekha and Prasad, 1993).

Although genotypic coefficient of variation helps to measure the genetic variability in a character, it is not possible to partition the heritable variation with this alone. The GCV together with heritability estimates would give the best result of the amounts of genetic advance to be expected from selection (Burton, 1951). High estimates of heritability were obtained for all the traits except, plant spread on both directions (East-West and North-South) and plant height, which had moderate to low heritability estimates (Table 2). This might be possible due to low impact of environment on these traits. Similar results were also recorded by (Uma *et al.*, 2000; Bisla nad Daulta, 1988). Maturity duration and plant spread on both sides were showed high heritability in spite of low GCV. This might be due to the introduction

of replication into the system (Burton and Devane, 1953).

The heritable variation can be estimated with greater degree of accuracy, when heritability is studied along with genetic advance. A high heritability coupled with high genetic advance gives most effective criteria for selection (Johnson *et al.*, 1955). Heritability along with genetic advance would be helpful in assessing the nature of gene action. In the present study, high heritability estimates coupled with high expected genetic advance as percentage of mean were observed for duration of dormancy, number of fruits per plant, flowering duration and yield (Table 2), indicating that heritability for the above characters might be due to the additive gene effects. Furthermore, these characters could be considered as reliable selection indices. This is in confirmation with the findings of (Bisla and Daulta, 1988). High heritability along with moderate to low genetic advance were noticed for E-W and N-S plant spread, maturity duration and plant-height indicating that these characters to be controlled by non-additive genes and improvement through selection for these traits would be rather ineffective. The high GCV, heritability and expected genetic advance as percentage of mean were observed for dormancy duration, number of fruits per plant, flowering duration and yield. Hence these traits could be used as selection criteria for development of effective and

Table 2. Estimates of genetic parameters for different morphological and yield characters in some pomegranate genotypes

Character	Range		Mean	Coefficient of variation		Heritability (%)	Genetic advance	Genetic grain (%)
	Min.	Max.		Phenotypic	Genotypic			
Plant height (cm)	2.20	3.20	2.77	10.30	8.51	68.3	0.40	14.44
East-West plant spread (m)	1.60	2.63	2.00	15.60	14.21	81.9	0.53	26.50
North-South plant spread (m)	1.57	2.53	1.96	15.10	13.30	77.6	0.47	23.97
Dormancy duration (days)	56.00	67.00	31.70	102.39	102.33	99.9	66.80	210.72
Flowering duration (days)	16.00	39.00	26.91	25.72	25.11	95.4	13.60	50.53
Duration from fruit set maturity (days)	120.00	155.00	136.00	7.31	7.21	97.4	19.95	14.66
Number of fruits per plant	18.67	56.00	35.18	28.70	28.70	95.8	19.93	56.65
Fruit yield (kg/plant)	4.75	11.60	7.02	25.79	24.87	93.0	3.47	49.43

productive plant type in pomegranate.

REFERENCES

- Bisla, S.S. and Daulta, B.S. 1988. Variability and heritability of some growth characters in ber (*Zizyphus mauritiana* L.). *Indian J. Hort.*, **45** : 29-33.
- Burton, G.W. 1951. quantitative inheritance in pearl millet (*Pennisetum glaucum*). *Agron. J.*, **43** : 409-417.
- Burton, G.W. and De Vane, E.W. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.*, **45** : 478-481.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron J.*, **47** : 314-318.
- Khodade, M.S., Wavhal, K.N. and Kale, P.N. 1990. Physico-chemical changes during growth and development of pomegranate fruit. *Indian J. Hort.*, **47** (1) : 21-27.
- Malhotra, V.K., Khajuria, H.N. and Jawanda, J.S. 1983. Studies on physico-chemical characteristics of pomegranate cultivars I. Physical characters. *Punjab Hort. J.*, **23** : 153-157.
- Rekha, A. and Prasad, M.B.N.V. 1993. Genetic variability and character association in banana. *Indian J. Hort.*, **50** (1) : 36-40.
- Uma, S., Dayarani, M., Singh, H.P., Shyam, B. and Sathiamoorthy, S. 2000. Studies on genetic variability in banana-Silk subgroup (AAB). *Indian J. Hort.*, **57** (2) : 106-109.

INFLUENCE OF PRECEDING CROPS AND FERTILIZER APPLICATION ON DRY MATTER ACCUMULATION, BIOMASS PRODUCTION AND UPTAKE OF N AND P BY MUSTARD [BRASSICA JUNCEA (L.) COSS & CZERN]

BHARTENDU MISHRA AND GAJENDRA GIRI

*Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

The results revealed that periodical dry matter accumulation per plant increased significantly due to preceding crops and their fertilization and direct application of N and P. Highest biomass yield was also recorded when mustard was grown after fertilized urdbean. Total dry matter and biomass was also highest when 80 kg N + 40 kg P₂O₅/ha was applied directly to mustard crop. On an average 80 kg N + 40 kg P₂O₅/ha increased the yield by 46 per cent over control. The total N and P uptake was significantly increased by fertilization of preceding crops and their fertilizer application was highest from mustard crop followed urdbean. The highest N and P uptake (143.7 kg N and 32.4 kg P₂O₅/ha) was recorded with 80 kg N + 40 kg P₂O₅/ha.

Key words : Preceding crops, fertilizer, dry matter, biomass N and P uptake and mustard.

Cropping systems based approach of nutrients application has more relevance than individual crop based. It is observed that nutrient management adopted in one crop often influence the fertilizer needs of the following crop(s) due to carry over effect of nutrients with the increase in irrigation potential, mustard has become an important partner in cropping system. Hence nutrient management of mustard based cropping system has become a need of present days. Favorable effect of *Sesbania* and succeeding Indian mustard has been reported by Sharma and Jain (2002). Since, fertilizer applied directly or in preceding crops by the large govern the biomass production and uptake of nutrients by influencing the nutrients availability in soil, it became imperative to study the effect of preceding crops and fertilizer applied to them on biomass production and nutrient uptake by mustard. With this view, the present experiment was planned and conducted.

MATERIALS AND METHODS

An experiment was conducted during kharif and rabi seasons of 2001-02 and 2002-03 at the farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi with the objectives to study the effect of preceding

crops, their fertilizer application and direct application of N and P on dry matter accumulation, total biomass production and uptake of N and P by mustard [*Brassica juncea* (L.) Coss & Czern]. The treatments consisting six practices of preceding season viz., maize, sunflower and urdbean with and without fertilizer formed main plots and four levels of fertilizer (control, 40 kg P₂O₅, 40 kg N + 40 kg P₂O₅ and 80 kg N + 40 kg P₂O₅/ha) as sub-plots. The experiment was conducted in a three times replicated split plot design. Maize, sunflower and urdbean were grown on 19 June and 15 July in two years, respectively and fertilized with recommended dose of 120 kg N + 50 kg P₂O₅, 80 kg N + 40 kg P₂O₅ and 20 kg N + 50 kg P₂O₅/ha, as per treatments respectively. In subsequent rabi season mustard cv. Pusa Jagannath was sown on 20 and 30 October in respective seasons.

RESULTS AND DISCUSSION

Dry matter accumulation

The data on dry matter accumulation per plant (Table 1) revealed the significant effect of preceding crops and their fertilizer application on periodical dry matter accumulation of mustard in both the years. The highest dry

Treatment

Treatment	Dry matter accumulation/plant (g)															
	2001-2002				2002-2003				2001-2002				2002-2003			
	45 DAS	90 DAS	135 DAS	45 DAS	90 DAS	135 DAS	Seed yield (q/ha)	Total biomass yield (q/ha)	HI (%)	Seed yield (q/ha)	Total biomass yield (q/ha)	HI (%)	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total N uptake (kg/ha)	Total P uptake (kg/ha)
Proceeding Treatments																
Maize without fertilizer	3.6	36.8	62	3.1	27.7	54.9	25.2	95.9	26.2	19.9	74.7	26.5	108	23.8	78.7	17.6
Maize with fertilizer	4.5	42.7	71.8	4.2	35.7	69	27.8	104.3	26.6	22.2	83.9	26.3	120	30	95.5	23.1
Sunflower without fertilizer	3.8	38.7	66.7	3.3	28.1	58.8	28.2	99.2	28.4	19.3	71.5	27	117	26.2	77.8	17
Sunflower with fertilizer	4.7	44.8	84.2	3.9	34	65.7	29.8	110.4	26.8	20.5	78.5	26.2	129	32.1	86.8	21.2
Urdbean without fertilizer	4.6	43.4	71.8	4.3	36	67.2	30.7	109	28.1	21.4	78.7	27.3	131	28.9	89.6	19.3
Urdbean with fertilizer	5.2	49.3	82.3	5	41.8	76.7	32.2	115.6	27.7	24	89.3	26.9	142	34.1	106.1	24.9
SE m ±	0.1	0.5	3.1	0.1	0.5	0.8	0.4	1.1	0.3	0.3	1.2	0.3	2.3	0.5	1.3	0.3
C.D. (P=0.05)	0.4	1.8	9.7	0.2	1.8	2.9	1.3	3.5	NS	1.1	3.8	NS	6.5	1.4	3.7	0.9
Fertilizer levels (kg/ha)																
0	2.9	26.8	48.9	2.5	22.3	43	23.8	94.5	25.3	17.1	65.4	26.2	91	18.7	60.6	12.7
40 kg P ₂ O ₅	3.8	38.5	58.5	3.2	29.4	51.8	26.5	101.3	26.2	20	76.7	26	108	28	78.7	19.5
40 kg N + 40 kg P ₂ O ₅	4.8	48.8	79.9	4.6	38.2	73	31.2	107.4	29	22.6	82.4	27.5	135	32.4	95.7	22.9
80 kg N + 40 kg P ₂ O ₅	6	56.3	105.1	5.6	45.5	93.8	34.4	119.8	28.7	25.2	93.2	27.1	166	37.7	121.4	27.1
SE m ±	0.1	0.7	2.7	0.1	0.5	0.8	0.3	0.9	0.4	0.3	0.8	0.4	1.9	0.4	1.11	0.2
C.D. (P=0.05)	0.2	2.1	8.1	0.2	1.5	2.8	0.8	2.5	1.1	0.7	2.2	1.1	5.3	1.1	3	0.7

matter was accumulated when mustard was taken after fertilized crop of urdbean at all the stages in both years. Unfertilized crop of maize caused to produce lowest amount of dry matter at all the stages of mustard. This was because unfertilized crop of maize exhausted the nutrients and resulted into lowest fertility status of soil. Whereas urdbean crop enhanced the N and P status in soil (Mishra, 2003).

The effect of direct application of N and P on dry matter/plant was also found to be significant at all the growth stages in two years. The highest dry matter was accumulated when 80 kg N + 40 kg P₂O₅/ha was applied to mustard crop (Table 1).

Biomass production

The biomass and seed yield of mustard was also significantly increased by preceding practices (Table 1). The fertilization of all these crops enhanced the biomass of mustard in both the years. The highest biomass and seed yield recorded when mustard crop was sown after fertilized urdbean in both the years. However, harvest index was not influenced by preceding crops and fertilizer applied to them.

The direct application of N and P to mustard crop also significantly increased the biomass and seed yield of mustard in two seasons. The highest production of seed yield (34.4 and 25.2 q/ha) was harvested when 80 kg N + 40 kg P₂O₅/ha was applied in both the years, respectively.

Whereas control plots produced only 23.8 and 17.1 q/ha in 2001-02 and 2002-03, respectively. P application did not influence the HI of mustard. But application of 40 kg N/ha significantly enhanced the harvest index of mustard in two years (Table 1). Kumar *et al.*, (2001) confirmed the results and reported significant increase in seed yield and HI up to 80 kg N/ha.

N and P uptake

The total N and P uptake by mustard crop was influenced by preceding treatments and their fertilizer application (Table 1). However, the highest N uptake was observed in mustard crop when grown after fertilized urdbean. The lowest N removal by mustard was recorded when unfertilized maize was grown before mustard in first year and unfertilized sunflower was grown in second year. Similarly, highest P uptake was observed when mustard was followed by fertilized urdbean in both the seasons. The N and P application also increased the N uptake in both the years. On an average 143.7 kg N/ha was removed when dose of 80 kg N and 40 kg P₂O₅ was applied. The effect of fertilizer levels also enhanced the uptake. On average highest P (32.4 kg) was removed when 80 kg N + 40 kg P₂O₅ was applied. Arthamwar *et al.* (1996) confirmed this findings and reported that 100 kg N and 80 kg P₂O₅ increase and N and P uptake by mustard. Meena *et al.* (2001) also reported progressive increase in P and N uptake was enhanced with increasing N rates.

REFERENCES

- Arthamwar, D.N., Shelke, V.B., Mundhe, P.R., Dhoble, M.V. and Ekahinge, B.S. 1996. Effect of nitrogen and phosphorus levels on yield and nutrient uptake by mustard. *J. Mah. Agric. Univ.*, 21(3) : 378-380.
- Kumar, A., Singh, D.P., Sing, B. and Yashpal. 2001. Effect of nitrogen application on partitioning of biomass, seed yield and harvest index in contrasting genotypes of oilseed brassicas. *Indian J. Agron.*, 46(1) : 162-167.
- Meena, B.S., Tanwar, S.P.S. and Sharma, G.L. 2001. Effect of nitrogen, irrigation and interculture on yield, nutrient content and uptake in mustard (*Brassica juncea* L. Czern & Coss). *J. Soil & Crops*, 11(2) : 184-187.
- Mishra, Bhartendu 2003. Influence of fertilizer application in preceding crops on the N and P response of mustard. Ph. D. Thesis, Division of Agronomy, IARI, New Delhi.
- Sharma, P.P. and Jain, K.K. 2002. Nitrogen requirement of Indian mustard (*Brassica juncea*) under different crop sequences. *Indian J. Agric. Sci.*, 72(2) : 101-103.

FODDER PRODUCTION POTENTIAL OF PURE AND INTERCROPPED CEREAL AND LEGUME FORAGES UNDER RAINFED CONDITIONS

B. GANGAIAH

*Regional Research Station, Indian Grassland Fodder and Agroforestry
Research Institute, UAS Campus, Dharwad - 580 005*

ABSTRACT

Field study was conducted to assess the fodder production of cereal (sorghum, bajra and maize) and legume (cowpea and horsegram) forages in pure and intercropping (additional series) systems during kharif at Dharwad. Based on mean green and dry fodder production (t/ha), sole maize and Cowpea proved superior to other cereal and legume crops, respectively. Intercropping of maize with cowpea/horsegram resulted in higher fodder production than other cereal and legume intercrops. Intercropping has resulted in significant reduction in yield of legumes whereas the yield of cereal remained unaffected though a 12% reduction was observed. The intercropping system was advantageous over sole cropping as is evident from higher LER and light utilization.

Key words : Pure, intercropping, LER, cereal and legume forages.

Jowar, bajra, and cowpea are the most important kharif cereal and legume forages crops of the country and Horse gram a legume crop of dry tracts of south. Cereal fodder's are poor in quality due to low protein and digestibility, whereas legume are rich in both these quality parameters. A combination of these crops can give quality fodder for animals. Intercropping is common in tropics and is known for increasing yield and quality of herbage besides economizing use of nitrogen (Singh *et al.*, 1985). Keeping these points in view, the present study was made to assess the fodder production potential of sole and intercropped cereal and legumes under rainfed conditions of North Transitional Zone of Karnataka.

MATERIALS AND METHODS

A two-year field study was conducted during kharif 1999 and 2000 at Saidapur farm of RRS, IGFARI, Dharwad. The soil was medium black with 0.82 and 0.84% of OC And 34 & 35 and 175 and 180 kg/ha of available P_2O_5 and K_2O during 1999 and 2000 respectively. The experiment was conducted

in RBD with 14 treatments formed by sole cereal (4), legume (2) and their intercrops (8) and was replicated thrice. The crops were sown in 30-cm rows at recommended seed rate. In intercropping system, a row of legume was introduced between two rows of cereal in additional series. The crops were sown on 3-7-1999 and 30-6-2000 and were harvested on 21-9-1999 and 7-9-2000 during 1999 and 2000, respectively. The varieties of crops used were African tall (maize), MP Chari in 1999 and SSV-74 in 2000 (sorghum), DRSB-1 & DRSB-2 (bajra), DFC-1 (cowpea) and DFB-1 (horsegram). A fertilizer dose of 90-40-40 and 20-40-40 kg/ha of $N-P_2O_5-K_2O$ was applied for sole cereal and legume respectively and no separate provisions were made for fertilizer for intercrop and thus it received same fertilizer dose as that of sole cereal crop. Entire NPK was applied as basal for legume. For sole cereal and intercropping systems entire PK along with $2/3$ N was applied as basal and rest $1/3$ N after weeding on 25th day of sowing. The Land Equivalent Ratio (LER) was arrived at by the formula :

$$\frac{\text{Yield of cereal in intercropping} + \text{Yield of legume in intercropping}}{\text{Yield of cereal as sole crop} + \text{Yield of legume as sole crop}}$$

The Light Transmission Ratio (LTR) was arrived by measuring light intensity at the top and ground level and expressed in %.

RESULTS AND DISCUSSION

Growth

The data presented in Table 1 shows that the crops differed for growth i.e. plant height, number of leaves/plant and leaf : stem ratio. Maize (1999) and jowar (2000) produced the tallest plants; However, their height was on par with Bajra (1999) and with bajra and maize (2000), respectively. During the second year, the plant height was highest with sorghum (SSV-74) whereas in the first year its (MP Chari) height was lowest. This was due to varietal differences with in the crop. The number of leaves/plant were significantly more in maize (mean 13.7) than Jowar (Mean 12.7) during first year and Bajra during both the years. The leaf: stem ratio was

significantly more in bajra (DRSB-2) i.e. 0.89 and was least for sorghum (0.59), and in legumes, it was significantly more in horse gram (1.84) than cowpea (1.37). The plant height, leaf number and leaf; stem ratio of cereal were not influenced by intercropping, however there is significant reduction in leaf; stem ratio of legume due to intercropping. The mean leaf ; stem ratio of cowpea was reduced from 1.38 to 1.09 during 1999 and from 1.35 to 1.09 during 2000 and the corresponding values for horse gram were 1.81 and 1.25 during 1999 and 1.86 to 1.33 during 2000, respectively. There were no tillers in maize and jowar, however barja has on average has 3 tillers/hill, hence data not presented.

Fodder yield

The data presented in Table 2 shows that the green and dry fodder (t/ha) production was significantly more by maize (60.7 and 13.62) than other cereals and was least by DRSB-1 bajra (41.1

Table 1. Growth of cereal legume forages under pure and intercropping

Crop	Plant height (cm)		Number of leaves/plant		Leaf : Stem ratio			
	Y1	Y2	Y1	Y2	Y1		Y2	
					C	L	C	L
Jowar (J)	209.4	282.5	11.4	13.9	0.57	-	0.61	-
Bajra (DRSB-1)	238.8	254.7	9.4	9.06	0.84	-	0.83	-
Bajra (DRSB-2)	254.3	249.2	9.9	9.8	0.90	-	0.88	-
Maize (M)	256.5	264.2	12.1	15.3	0.71	-	0.74	-
Cowpea (C)	145.7	155.3	-	-	1.35	1.35	1.38	1.38
Horsegram (Hg)	81.4	146.9	-	-	1.86	1.86	1.81	1.81
J + C	223.2	264.6	9.3	13.7	0.57	1.10	0.63	1.10
J + Hg	231.8	279.63	10.2	14.3	0.57	1.33	0.62	1.28
J + C	225.4	241.0	9.3	9.8	0.83	1.08	0.82	1.07
J + Hg	223.4	265.8	9.3	10.1	0.83	1.28	0.82	1.18
J + C	258.6	252.3	9.3	9.2	0.90	1.09	0.88	1.10
J + Hg	214.9	258.7	9.3	9.8	0.87	1.31	0.89	1.24
J + C	253.4	289.5	11.9	15.8	0.72	1.09	0.75	1.07
J + Hg	242.2	286.2	11.2	15.3	0.72	1.39	0.75	1.29
SEm±	11.9	11.6	0.3	0.4	0.02	0.04	0.02	0.03
C.D. 5%	34.6	33.7	1.0	1.3	0.05	0.12	0.05	0.10
C.V.%	9.4	8.1	5.8	6.0	3.55	5.29	3.55	4.50

Note : Y1 = 1999 and Y2 = 2000 and C = Cereal and L = Legume.

Table 1. Fodder performance, LER and LTR of cereal and legume forages under pure & intercropping

Crop	Green fodder yield (t/ha)				Dry fodder yield (t/ha)				LER		LTR (%)
	Y1		Y2		Y1		Y2		Y1	Y2	Y2
	C	L	C	L	C	L	C	L			
Jowar (J)	34.7	-	64.9	-	8.14	-	14.24	-	1.00	1.00	8.73
Bajra (DRSB-1)	38.1	-	44.0	-	6.47	-	7.51	-	1.00	1.00	8.78
Bajra (DRSB-2)	40.0	-	52.9	-	6.81	-	9.30	-	1.00	1.00	8.48
Maize (M)	49.2	-	72.2	-	11.06	-	16.18	-	1.00	1.00	10.38
Cowpea (C)	27.5	27.5	26.1	26.1	5.43	5.43	5.50	5.50	1.00	1.00	4.22
Horsegram (Hg)	14.4	14.4	22.0	22.0	2.57	2.57	3.78	3.78	1.00	1.00	4.06
J + C	31.1	14.7	62.5	12.6	6.95	2.97	13.68	2.46	1.40	1.36	2.37
J + Hg	32.8	10.3	53.5	10.7	7.54	1.81	11.84	1.82	1.63	1.43	2.18
J + C	34.4	12.8	31.3	11.9	5.81	2.84	5.25	2.33	1.42	1.44	2.64
J + Hg	31.1	7.5	41.0	10.6	5.49	1.29	6.98	1.73	1.40	1.35	2.67
J + C	35.8	14.7	45.0	11.7	6.14	2.71	7.91	2.28	1.40	1.17	2.56
J + Hg	35.3	10.0	43.6	9.0	6.50	1.51	7.88	1.53	1.54	1.47	2.41
J + C	42.2	13.9	64.6	12.2	9.479	2.36	14.80	2.42	1.32	1.29	2.79
J + Hg	44.5	8.9	65.8	11.0	10.14	1.50	14.75	1.80	1.50	1.18	2.56
SEm±	3.3	1.3	5.2	1.7	0.66	0.27	0.99	0.32	0.10	0.12	0.28
C.D. 5%	9.7	4.0	15.1	5.2	1.92	0.81	2.87	0.96	0.30	0.35	0.80
C.V. %	14.0	17.5	18.2	21.9	16.2	17.3	17.1	21.8	14.0	17.4	10.37

Note : Y1 = 1999 and Y2 = 2000 and C = Cereal and L = Legume.

and 6.99), however the fodder production of jowar (SSV-74) was on par with maize during second year. The superiority of maize during both the years and sorghum during second year was attributed to their more plant height. Among the legumes, cowpea fodder production (26.8 and 5.47 t/ha of green and dry) was significantly more than that of horsegram. (18.2 and 3.18).

Intercropping of cereal with legume has resulted in a significant reduction in yield of legume, while the yield of cereal remain unaffected. The mean reduction in green fodder yield of legume was 51.25 and 44.8% in cowpea and horse gram respectively. This reduction in fodder production of legume was possibly due to shading by cereal component and competition for soil resources. The shading was evident from amount of light transmitted to the ground level. The light Transmission (%) was significantly more for maize (10.38) than all other cereals and

the corresponding values were 8.73 (jowar), 8.28 (DRSB-1, bajra) and 8.48 (DRSB-2 barja) and was least for Horse gram (4.06) and its value for cow pea was 4.22 among sole crops. Intercropping has resulted in significant reduction in light transmission i.e. by 38.6 and 39.2%, respectively with cowpea and horse gram over sole legume crops and thus indicating efficient utilization of light by intercropping system. The mean reduction in green fodder yield of cereal was 12.8 and 11.3% due to intercropping with cow pea and horse gram respectively and the crop wise mean yield reduction % were 9.2, 14.6, 13.6 and 10.7 in sorghum, DRSB-1, DRSB-2 (bajra) and maize, respectively. However the total productivity increased due to intercropping over sole cropping. Intercropping of maize + cowpea resulted in highest green and dry (t/ha) fodder production with a mean of 53.4 and 13.01 + 12.30 and 2.39 closely followed by maize + horse gram

i.e. 55.15 and 12.45 + 9.95 and 1.65 the next best intercropping combination is jowar + cowpea. bajra (DRSB-1) intercropping is least performing combination. A similar yield advantage due to intercropping of maize (Tripathi *et al.* 1997) Teosinte (Choubey *et al.*, 1997) with cowpea, sorghum (Mishra *et al.*, 1997) with cowpea and horse gram and Bajra (Joshi, 1999) with mungbean over their sole crops were reported.

Land equivalent ratio (LER)

The advantage of intercropping system as measured by LER indicated that intercropping has resulted increasing its value above unity. The

mean LER values (mean over cereals and years) were 1.35 and 1.44 for cow pea and horse gram respectively and the mean LER values for cereals (mean over legumes and 2 years) were 1.46, 1.41, 1.40 and 1.32 for jowar, DRSB-1 & DRSB-2 (bajra) and maize, respectively. A similar increase in LER, due to intercropping of cereal with legume was obtained by Tripathi *et al.* (1997).

From the above study, it can be concluded that, intercropping of maize with cowpea/horse gram as ideal for higher and quality fodder production under rainfed situations in North Transitional zone of Karnataka.

REFERENCES

- Choubey, S., Bhagat, R.K. and Srivastava, V.C. 1997. Effect of planting pattern on forage production of Teosinte (*Euchlaena mexicana*) + cowpea (*Vigna unguiculata*) intercropping. *Indian J. Agron.*, **42** (3) : 429-431.
- Joshi, N.L. 1999. Effect of component densities on the performance of pearl millet-mungbean intercropping system under different rainfall situations in an arid environment. *Annals of Arid Zone*, **38**(1) : 15-25.
- Mishra, R.K. Choudhary, S.K. and Tripathi, A.K. 1997. Intercropping of cowpea (*Vigna unguiculata*) and Horse gram (*Macrotyloma uniflorus*) with sorghum for fodder under rainfed conditions. *Indian J. Agron.*, **42** (1) : 38-41.
- Singh, V., Joshi, Y.P. and Verma, S.S. 1985. Studies on the forage based cropping system, National Seminar on cropping system. Indian Society of Agronomy, 21-25, February, New Delhi.
- Tripathy, R.K., Pradhan, L. and Rath, B.S. 1997. Performance of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) forage intercropping system in summer. *Indian J. Agron.*, **42**(3) : 405-408.

EFFECT OF NITROGEN AND ZINC ON WHEAT IRRIGATED WITH ALKALI WATER

Y.P. SINGH

*Krishi Vigyan Kendra
Banasthali Vidyapith, Tonk - 304022 (Rajasthan)*

ABSTRACT

A field experiment on wheat was carried out during rabi season of 1998-2000 on an alkali water irrigated loamy sand soil for evaluating the effect of nitrogen (0, 90.0, 112.5 and 135.0 kg N/ha) and zinc. The pooled data revealed that growth and yield of wheat significantly increased progressively with increasing levels of N up to 112.5 kg/ha. Similarly, highest incremental cost : benefit ratio (ICBR) 1:5.04 was estimated with 112.5 kg N/ha application. The application of 5.0 kg Zn/ha significantly increased growth and yield of wheat over control, whereas at par with 6.25 and 7.5 kg Zn/ha. The highest ICBR 1:5.72 was estimated with 5.0 kg Zn/ha. The application of N significantly increased the N, P, and Zn content, whereas Na content in grain and straw decreased. The application of Zn significantly increased the N and Zn content and decreasing trend of P and Na content was observed in grain and straw.

Key words : Alkali water, nitrogen, zinc, wheat yield and nutrient content.

Alkali water constitutes 37% of the underground brackish waters in some states of north-western India (Yadav and Kumar, 1995). When these types of waters are used for irrigation, calcium gets immobilized due to its precipitation as calcium carbonate, resulting in excessive saturation of soil with sodium and increase pH and exchangeable sodium percentage. The high sodium and pH adversely affects the transformation of applied nutrients. Singh and Bajwa (1989) observed that increase in salinity and alkalinity shows down the rate of ureas hydrolysis. Ammonia volatilization may be a major losses mechanism, water containing bicarbonate are used for irrigation. Alkali water high in bicarbonates decrease the availability of Zn, Mn, Fe and Cu but Zn is one of the most important nutrients limiting crop production. Keeping in view the above facts studies was undertaken on effect of nitrogen and zinc in wheat irrigated with alkali water.

MATERIALS AND METHODS

A field experiment was conducted on wheat crop during rabi seasons of 1998-99 and 1999-2000 on loamy sand soil (pH-8.6, EC-0.49 ds/m), irrigation with alkali water (ECIW-2.6 ds/m, RSC-7.4 me/l and SAR-4.68; Ca-1.8, Mg-3.8,

Na-7.84, K-0.19, HCO_3 -10.0, CO_3 -3.0 and Cl-13.5 me/l) on farmers field at Lodheda village of Tonk district of Rajasthan. Alkali water had been used by the farmer from last 5 years with occasional application of gypsum as per soil test in variable crop rotations. The surface soil (0.15m) had an initial organic carbon - 0.15%, calcium carbonate - 0.62%, available N - 124.0 kg/ha, P - 13.6 kg/ha, K - 256.0 kg/ha and Zn-0.49 mg/kg. The treatment comprised of 4 levels of nitrogen and zinc viz. control, recommended dose for normal condition of this zone (90.0 kg N/ha and 5.0 kg Zn/ha), 1.25 and 1.5 times of recommended doses, respectively. The N and Zn were applied as urea and zinc sulphate, respectively. These treatments were replicated three times in a factorial randomized block design in the plot size 2.0×4.0m². Recommended dose of phosphorus i.e. 60 kg P₂O₅/ha as single super phosphate was also applied before sowing of the crop. Wheat variety Raj-3077 was sown on 25 and 28 November during the first and second year of experimentation following all packages of practices. Grain and straw samples of wheat were analyzed for content of N, P, K, and Na and Zn. The N content was determined with the help Kjeltac-II auto analyzer. The P content was determined in acid extract by

Chapman and Pratt (1961). The K, Na and Zn were estimated in the same extract after making suitable dilution and the concentration measured with the help of flame photometer and automatic absorption spectrophotometer, respectively.

RESULTS AND DISCUSSION

Pooled data revealed that the height of plants, tillers, test weight and yield of wheat significantly increased progressively increasing levels of N up to 112.5kg/ha, which was at par with 135.0kg N/ha (Table 1). Increasing levels of N up to 112.5kg/ha increased significantly the grain and straw yield of wheat from 3118 to 3958kg/ha and 4277 to 6163kg/ha, respectively. Average grain and straw yield response of 112.5kg N/ha was 840 and 1886kg/ha with corresponding yield increase of 26.9 and 44.1%, respectively. Singh and Bajwa (1989) observed that alkali water irrigation slows down the rate of urea hydrolysis. Ammonia volatilization may be a major loss mechanism when water contain bicarbonates are used for irrigation. The results are in agreement with the finding of Yadav and Verma (1991) and Lal and Lal (1990).

Application of 5.0kg Zn/ha significantly the

tillers, test weight and yield over control (Table1). There was no further increase in tillers, test weight and yield with 6.25 and 7.5kg Zn/ha application over 5.0kg Zn/ha. Application of 5.0kg increased the pooled grain yield from 3315 to 3886kg/ha and straw yield from 4906 to 5605kg/ha with correspond yield response of 571 and 699kg/ha, which account for 17.2 and 14.3%, respectively. Singh and Tripathi (1974) reported that zinc is essential component of protein, chlorophyll and enzymes. The results of the present investigation are in accordance with Yadav and Verma (1991) and Lal and Lal (1990).

The application of 90, 112.5 and 135.0kg N/ha the incremental cost : benefit ratio (ICBR) was 4.67, 5.04 and 4.76, respectively (Table 1). Similarly, the application of 5.0, 6.25 and 7.50kg Zn/ha ICBR was 5.72, 4.73 and 4.18, respectively. The maximum incremental cost : benefit ratio (ICBR) was associated with 112.5kg N and 5.0kg Zn/ha.

The application of N and Zn significantly increased the N content of grain and straw of wheat (Table 2). The increase in N content of grain with the application of 90.0, 112.5 and 135.0kg N/ha 5.0, 6.25 and 7.5kg Zn/ha was to

Table 1. Average effect of nitrogen and zinc on growth, yield and ICBR of wheat

Treatments	Plant height (cm)	Number of tillers/plant	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	ICBR
N levels (kg/ha)						
Control	80.79	5.80	35.91	3118	4277	-
90.0	88.50	6.11	38.15	3808	5366	1:4.67
112.5	94.76	6.42	40.05	3958	6163	1:5.04
135.0	92.92	6.49	40.10	4096	6366	1:4.76
SEm±	1.39	0.10	0.78	57	82	-
CD (P=0.05)	4.02	0.29	1.66	163	237	-
Zn levels (kg/ha)						
Control	85.28	5.94	37.03	3315	4906	-
5.00	90.42	6.25	38.81	3886	5605	1:5.72
6.25	90.63	6.30	39.09	3905	5752	1:4.73
7.50	90.64	6.33	39.28	3934	5939	1:4.18
SEm±	1.39	0.10	0.78	57	82	-
C.D. (P=0.05)	4.02	0.29	1.66	163	237	-

Urea @ Rs. 9.57/kg N; Zinc sufphat @ Rs 114.29/kg Zn; Price of wheat @ Rs. 5.5/kg grain and Rs 1.0/kg Straw; ICBR (Incremental Cost : Benefit Ratio).

Table 2. Mean effect of nitrogen and zinc on nutrient content in grain and straw of wheat

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sodium (%)		Zinc (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
N levels (kg/ha)										
Control	1.75	0.422	0.45	0.16	0.425	1.40	0.192	0.400	24.88	16.70
90.0	1.91	0.474	0.49	0.21	0.427	1.46	0.183	0.362	26.12	17.98
112.5	1.97	0.512	0.50	0.24	0.429	1.49	0.181	0.357	26.91	18.73
135.0	2.02	0.528	0.52	0.26	0.432	1.51	0.175	0.347	27.98	19.39
SEm ±	0.009	0.0045	0.0037	0.002	0.0067	1.0017	0.0016	0.0024	0.24	0.134
C.D. (P=0.05)	0.026	0.013	0.011	0.005	NS	NS	0.0047	0.007	0.69	0.387
Zn levels (kg/ha)										
Control	1.81	0.431	0.51	0.25	0.426	1.43	0.191	0.371	23.47	14.41
5.00	1.90	0.492	0.50	0.22	0.427	1.46	0.182	0.363	25.83	17.73
6.25	1.95	0.511	0.48	0.21	0.429	1.48	0.181	0.359	27.65	19.98
7.50	1.99	0.515	0.47	0.19	0.431	1.49	0.176	0.352	28.94	20.78
SEm ±	0.009	0.0045	0.0037	0.02	0.0067	0.0174	0.0016	0.024	0.24	0.134
C.D. (P=0.05)	0.026	0.013	0.011	0.005	NS	NS	0.0047	0.0069	0.69	0.387

the tune of 5.0, 7.7 and 9.9% as compared to control, respectively. Similarly, the N and Zn application increased the N content of wheat straw (Lal and Lal, 1990).

Phosphorus content of grain and straw of wheat to increase significantly with the application of N and maximum P content in grain (0.52%) and straw (0.26%) were noted under higher level of N i.e. 135.0kg/ha (Table 2). The application of Zn significantly decreased the P content of grain and straw of wheat. Maximum value of P content of grain (0.51%) and straw (0.25%) was recorded under control plots whereas, minimum P content at higher level of Zn application. The application of N and Zn did not significant influence on K content in grain and straw of wheat. Lal and Lal (1990) have reported similar findings.

The Na content of grain and straw tended to decrease significantly with the application of nitrogen. Maximum value of Na content was recorded under control (0.192% in grain and 0.40% in straw) and minimum value (0.175% in grain and 0.347% in straw) at 135.0kg N/ha application. This can be explained on the basis

that concentration of ammonium ions (NH_4^+) increased in soil solution due to application of nitrogen, which in turn replaced the Na from the exchange site thereby absorption of Na by plant decreased. Lal and Lal (1990) have also reported similar findings. Similar trend of Na content in grain and straw with Zn application was also recorded. The Na content of grain and straw tended to decrease significantly with application of Zn. This may be due to the fact that on the exchanges sites, Zn replaced the Na, which led to more uptake of Zn and less uptake of Na (Reddy and Yava, 1994).

The N and Zn application increased significantly Zn content in grain and straw of wheat. Maximum zinc content (27.98ppm in grain and 19.39ppm in straw) recorded with 135.0kg N/ha and minimum values (24.88ppm in grain and 16.70ppm in straw) in control plot. Similarly, maximum content of Zn (28.94ppm in grain and 20.78ppm in straw) recorded with 7.5kg Zn/ha and minimum content of Zn (23.47ppm in grain and 14.41ppm in straw) in control. These findings are in close harmony of the results reported by Singh and Tripathi (1974) and Yadav and Verma (1991).

REFERENCES

- Chapman, H.D. and Pratt, P.G. 1961. Method of analysis for soil, plants and water. *Division Agric. Sci. Univ. California, U.S.A.*
- Lal, R. and Lal, P. 1990. *Agrokem*, Talajet, 39: 63-73.
- Reddy, D.D. and Yadav, B.R. 1994. *J. Indian Soc. Soil Sci.*, 42 : 594-597.
- Singh, B. and Bajwa, M.S. 1989. *J. Indian Soc. Soil Sci.*, 39 : 779-780.
- Singh, D.V. and Tripathi, B.R. 1974. *J. Indian Soc. Soil Sci.*, 22 : 244-248.
- Yadav, G.L. and Verma J.K. 1991. *Indian J. Agron.*, 36 : 50-56.
- Yadav, H.D. and Kumar, V. 1995. Proceedings of Nat. Sem. On Reclamation and Management of Water-Logged Saline Soil", CSSRI, Karnal and HAU, Hissar, pp226

INFLUENCE OF AQUEOUS LEAF EXTRACT OF BER ON GERMINATION AND SEEDLING GROWTH OF COWPEA AND FENUGREEK

P.L. SAROJ, C.K. PUROHIT, R. BHARGAVA AND B.D. SHARMA

Central Institute for Arid Horticulture, Bikaner - 334 006, Rajasthan

ABSTRACT

The present study is an effort to assess the interaction effects of perennial component ber (*Ziziphus mauritiana*) on two important annual field crops i.e. cowpea (*Vigna unguiculata*) and fenugreek (*Trigonella foenumgraecum*) of the hot arid ecosystem of western Rajasthan. The laboratory bioassay studies revealed that the aqueous leaf extracts of ber reduced the germination of both the crops but effect was more pronounced in case of fenugreek. In almost all the vigour parameters and phytomass production, the inhibitory effect was more in fenugreek as compared to cowpea except number of roots/plant which indicated to sensitivity of fenugreek to allelochemicals present in the aqueous extracts of ber leaves.

Key words : Agroforestry, allelopathy, aqueous leaf extracts, ber, cowpea.

The integration of woody perennials on farmlands is an age-old practice of the farming community. Based on the experiences, farmers of the hot arid regions are growing a variety of annual crops with different perennial components, without ascertaining interactions between them. Ber based agroforestry systems are becoming popular in recent years in arid and semi-arid regions of the country. These systems allow sustainable and diversified production at an economically acceptable level with minimal use of external inputs. Integration of ber in developing various agroforestry systems yields multiple outputs. Apart from precocity and prolific bearing habits, it also enriches organic matter to growing site owing to its deciduous nature (Saroj *et al.*, 2002). Therefore, the present investigation was aimed to establish the allelopathic influence of ber on two important crops of the region viz., cowpea (*Vigna unguiculata*) and fenugreek (*Trigonella foenumgraecum*).

MATERIALS AND METHODS

The laboratory bioassay studies were conducted at Central Institute for Arid Horticulture, Bikaner during 2001-2002.

i) Preparation of ber leaf aqueous extracts

Fully mature and about to senescence

leaves of ber cultivar Gola were collected from field plantation of Research Farm, CIAH, Bikaner. The leaf samples were washed gently with tap water only for few seconds to avoid leaching losses of water-soluble allelochemicals followed by quick rinsing in distilled water and were dried with clean blotting paper. The samples were kept in an oven at 60°C till constant weight and then ground to fine powder in a Wiley Mill followed by sieving through 2-mesh (0.846 screen). The resultant powdered material was mixed thoroughly to prepare a representative sample. The leaf powder (20 g) was soaked in 1 lit. Distilled water and then shocked rigorously for 25 minutes. The sample was kept for overnight at room temperature in order to allow complete dissolving of water-soluble allelochemicals in the solvent i.e. distilled water. The sample was filtered through muslin cloth and filtrate was again filtered through What man filter paper No. 1 to remove suspended particles (Narwal, 1994).

ii) Experimental methodology

Fresh, uniform and healthy seeds of cowpea and fenugreek were surface sterilized with 0.1 per cent mercuric chloride (HgCl_2) for five minutes followed by five quick washes with distilled water and were air dried under shade. Twenty seeds of both the crops were placed in

pre-sterilized petri plates (15 cm diam.) on double lined moist filter paper and kept at room temperature. Seven milliliter of aqueous extracts of ber leaves or distilled water (control) was added to each petri plate and thereafter five milliliter everyday upto 4 days. The emergence of radicle was considered as criterion for seed germination, five seedlings of both the crops were selected randomly and were planted carefully, keeping intact all its parts into poly-containers filled with sand medium as test plants for subsequent growth studies. Ten ml of same extracts or distilled water was added everyday up to 15 days to each poly-containers as per treatment. At the termination of experiment (i.e. after 15 days), data on seedling vigour parameter were recorded. The vigour index (VI) was computed following the method suggested by Abdalbaki and Anderson (1973). After recording fresh weight of seedlings, the samples were kept in an oven at $60 \pm 2^{\circ}\text{C}$ for 24 hours for dry weight estimation. The experiment was conducted in both rabi and kharif seasons for fenugreek and cowpea, respectively by adopting same methodology. To test the statistical significance of the treatments, data were analyzed by using 't' test.

RESULTS AND DISCUSSION

The response is clearly depicted in fig. 1 that germination started after 24 hrs in both the test crops irrespective of the treatments and maximum seeds were germinated (92.2%) in cowpea and 77.8% in fenugreek over their control i.e. 96.8% and 90.0%, respectively, within 96 hrs and thereafter, no increase in germination was observed. However, the rate of germination was faster in cowpea than fenugreek (Table 1) and after 72 hrs, there was only marginal increase in germination of cowpea but marked increase in germination of fenugreek was recorded.

The inhibitory effect of ber leaf aqueous extract was quite apparent right from the first day. The data presented in Table 1 revealed that germination percent in both the test crops was not only delayed but also reduced to a significant level by ber leaf aqueous extracts. The reduction in germination per cent was more (13.55%) in fenugreek as compared to cowpea (6.82%).

Statistically significant per cent reduction in germination of treated seeds over control (distilled water) in both cowpea and fenugreek crops could be attributed due to the inhibitory activities of water-soluble allelochemicals that are probably present in ber leaf aqueous extracts. The per cent reduction in germination of cowpea seeds is nearly half than that of fenugreek and this could be because of bigger seed size of cowpea as compared to fenugreek. The interaction of water-soluble allelochemicals with the physiological reactions of the germinating seeds might have some relation with the seed size. Small seeded annual crops are more sensitive to aqueous leaf extracts of perennial crops as compared to relatively bigger sized seeded annual crops.

The treatment of ber leaf aqueous extracts has certain influence on various seedling vigour parameters viz., shoot length, root length and number of roots/plant (Table 2). The shoot length was considerably reduced in cowpea seeds treated with ber leaf aqueous extracts though it was statistically non-significant but per cent reduction (42.51%) in fenugreek seeds treated with ber leaf aqueous extracts was highly significant over the control. The per cent reduction in root length of cowpea (9.21%) and fenugreek (21.65%) over their respective controls was statistically non-significant but it was reduced marginally. Similarly, there was no effect of ber leaf aqueous extracts on the number of roots/plant in fenugreek as both treated and control seeds produced same number of roots/plant but it was significantly different in case of cowpea where, as high as 46.66 per cent reduction was recorded in treated seeds over control (Table 2).

The root : shoot ratio was high in treated seeds of both the test crops but it was more in fenugreek due to the emergence of small sized shoots in treated seeds which eventually resulted in high root : shoot ratio. In case of vigour index (VI), similar trend was followed in both the test crops. The vigour index of treated seeds was low as compared to control. The vigour index was reduced to almost half in the treated seeds of fenugreek against control, whereas in cowpea, the reduction was only up to 20 per cent. In

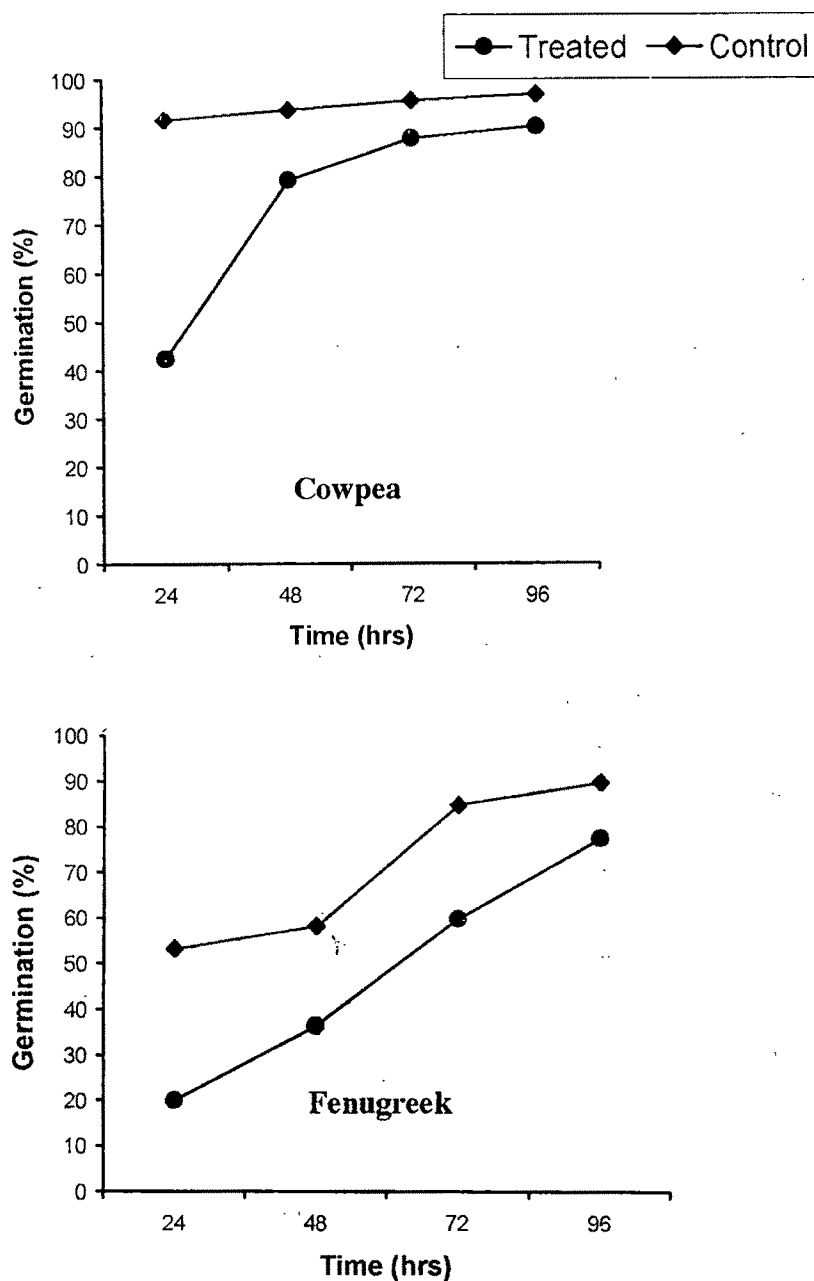


Fig. 1. Effect of ber leaf aqueous extracts on germination of groundstorey crops

fenugreek, it is clear that both germination per cent and shoot length were reduced significantly, resulting into low vigour index as against control.

Although, seedling phytomass of both the test crops was influenced by ber leaf aqueous

extract resulting into a considerable per cent reduction in fresh as well as dry weight but the per cent reduction in cowpea seedlings was non-significant. In case of fenugreek, there was 32.42 per cent reduction in fresh weight of treated seeds over control, which was statistically

Table 1. Per cent increase in germination at different intervals

Crop/Treatment	Time interval (hrs.)			
	24	48	72	96
Cowpea				
Treated	– (42.4)*	87.03 (79.3)	10.71 (87.8)	2.73 (90.2)
Control	– (91.7)	2.18 (93.7)	2.03 (95.6)	1.26 (96.8)
Fenugreek				
Treated	– (20.0)	83.0 (36.6)	63.93 (60.0)	29.66 (77.8)
Control	– (53.3)	28.14 (68.30)	24.45 (85.0)	5.88 (90.0)

* - Value in parentheses are actual germination per cent

Table 2. Effect of ber leaf aqueous extracts on seed germination, seedling vigour and dry matter production of cowpea and fenugreek

Groundstorey crops	Response#		Reduction (%)*	't' value**
	Treated	Control		
Cowpea				
Germination (%)	90.2 (±2.049)	96.8 (±1.92)	6.82	5.25 (0.006)
Shoot Length (cm)	18.78(±2.145)	21.44 (±1.299)	12.41	2.371 (0.076)
Root Length (cm)	4.14 (±0.512)	4.56 (±0.492)	9.21	1.320 (0.257)
No. of roots/plant	3.2 (±0.836)	6.0 (±1.0)	46.66	4.801 (0.008)
Root : Shoot	0.220	0.212	-	-
Vigour index	1693.96	2075.39	-	-
Fresh weight (g)	0.3602 (±0.068)	0.4218 (±0.027)	14.18	1.923 (0.126)
Dry weight (g)	0.0337 (±0.0048)	0.0409 (±0.0040)	17.60	2.533 (0.064)
Fenugreek				
Germination (%)	77.8 (±7.94)	90.0 (±4.89)	13.55	2.921 (0.043)
Shoot length (cm)	1.92 (±0.334)	3.34 (±0.357)	42.51	6.481 (0.002)
Root Length (cm)	1.52 (±0.258)	1.94 (±0.350)	21.65	2.154 (0.097)
No. of roots/plant	2.0(±0.0)	2.0 (±0.0)	-	-
Root : Shoot	0.791	0.580	-	-
Vigour index	149.38	300.60	-	-
Fresh weight (g)	0.0148 (±0.0031)	0.0219 (±0.00404)	32.42	3.084 (0.036)
Dry weight (g)	0.00236 (±0.0016)	0.00272 (±0.0010)	13.23	0.414 (0.750)

- Value in parentheses are SD value, * - per cent reduction over control, ** - value in parentheses are 'p' value

significant whereas, dry weight proved to be non-significant. The significant per cent reduction in fresh weight of fenugreek is due to inhibitory effects of ber leaf aqueous extracts on shoot and root length, which were reduced to a greater extent as compared to cowpea.

Both stimulatory and inhibitory effects of some perennials on fresh and dry weight of annual crops have been reported by some earlier workers. Saroj *et al.* (2002) reported inhibitory effect of *Ziziphus mauritiana* on dry weight of wheat and mustard and stimulatory effect on

fresh and dry weight of cluster bean. Similar stimulatory effects of some perennials on growth and phytomass of annual crops have also been reported by Bisla *et al.* (1992). Narwal and Tauro (1994) and Taheruzzaman and Kushari (1995), which support the findings of the present investigation.

From the interpretation of the results of present investigation, it can be concluded that fenugreek is more sensitive to water-soluble allelochemicals present in ber leaf aqueous extracts, whereas cowpea is a bit tolerant. Some previous studies have also shown this selectivity

of interferences of perennial components on annual crops. The classical example of walnut also support the selectivity where, quince, black raspberry, carrot, bean and maize proved resistant to Juglans and grew better within root zone sphere of the walnut trees than outside whereas, tomato, potato, apple, etc. have sensitive nature when grown under Juglans (Rietveld, 1983).

ACKNOWLEDGMENTS

We are thankful to the Indian Council for Agricultural Research, New Delhi for financial assistance under NATP.

REFERENCES

- Abdul-baki, A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Sciences*, 13 : 630-633.
- Bisla, S.S., Nandal, D.S. and Narwal, S.S. 1992. Influence of aqueous leaf extracts of eucalyptus and poplar on germination and seedling growth of winter crops. In : proceedings of First National Symposium on Allelopathy in Agro-ecosystems, HAU, Hissar. (Eds. P. Tauro and S.S. Narwal) pp. 95-97.
- Narwal, S.S. and Tauro, P. 1994. Allelopathy in Agriculture and Forestry. Scientific Publishers, Jodhpur. pp. 312.
- Rietveld, W.J. 1983. Allelopathic effect of Juglans on germination and growth of several herbaceous and woody species. *J. Chemical Ecology*, 9(1) : 295-308.
- Saroj, P.L. Sharma, B.D., Bhargava, R. and Purohit, C.K. 2002. Allelopathic influence of aqueous leaf extracts of ber (*Ziziphus mauritiana* L.) on germination, seedling growth and phytomass of groundstorey crops. *Indian J. Agroforestry*, 4(1) : 57-61.
- Taheruzzaman, Q. and Kushari, D.P. 1995. Effect of leaf leachate enriched water of neem (*Azadirachta indica*) on the germination of *Azolla pinnata*. *Environment and Ecology*, 13 : 589-594.

EFFECT OF INTEGRATED WEED MANAGEMENT ON YIELD COMPONENTS, YIELD AND ECONOMICS OF BABY CORN (ZEA MAYS)

SUBHENDU MANDAL, SUBIMAL MONDAL* AND SUBHADEEP NATH*

*Department of Agronomy
College of Agriculture, ANGRAU, Rajendranagar, Hyderabad, A.P.-500 030*

ABSTRACT

A field experiment was conducted to study the effect of integrated weed management on yield components, yield and economics of baby corn. Pre-emergence application of atrazine @ 1 kg ai ha⁻¹ + one hand weeding 30 days after sowing (DAS) recorded higher number of cobs per plant, weight of cob with husk and without husk followed by two hand weeding 20 and 40 DAS, both of which were at par with each other but significantly superior over all other treatments. Cob yield with husk, baby corn and fodder yield also followed same trend. However, highest gross return, net return and benefit cost ratio were recorded with atrazine @ 1 kg ai ha⁻¹ + one hand weeding 30 DAS.

Key words : Integrated weed management, yield, baby corn.

Baby corn refers to young flowering maize cob harvest within 2-3 days of silk emergence. The lack of knowledge of use and production technology seem to be the major constraints for popularization among the cultivators. It is used as vegetable as well as salad. Baby corn is one of the major rainy season vegetable of Andhra Pradesh. So, severe weed infestation is one of the major reasons of low productivity of baby corn. Mechanical or manual weeding is difficult due to continuous rains prevailing during rainy season and also due to scarcity and higher cost of manual labour. Although weed management in maize by herbicides application is well known, but information the effect of herbicides on yield components, yield and economics is meager. Therefore, an attempt was made to study the effect of herbicides on yield component, yield and economics of baby corn.

MATERIALS AND METHODS

A field experiment was conducted during rainy seasons of 1999 and 2000 at College Farm, Acharya, N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design replicated thrice. The plot size was 6 m × 3m. Treatments

comprised seven weed control measures (Table 1).

Variety Early Composite was sown on 15 the June, 1999 and 14 June, 2000 and harvested during August in both the years. Half dose of N (50 kg ha⁻¹), full dose of P₂O₅ (60 kg ha⁻¹) and K₂O (40 kg ha⁻¹) was applied at sowing and remaining half of N top dressed at 25 days after sowing. The crop was raised under irrigated condition with the application of 2-3 each year. The immature cobs (baby corn) were harvested at 2-3 days of silk emergence stage and marketed as fresh @ Rs. 25 q⁻¹ after de-husking. The crop was harvested as green fodder after the completion of cob picking and sold @ Rs. 25 q⁻¹. The economics of baby corn production was worked out by calculating operational cost, gross return, net return and benefit cost ratio.

RESULTS AND DISCUSSION

Yield components and yield

Data pertaining to effect of the weed control treatments on yield and its components are presented in the Table 1. Yield components like cobs per plant, cob weight with husk and cob weight without husk were significantly higher with treatment W₅ which received pre-emergence application of atrazine @ 1 kg ai ha⁻¹ + one hand weeding 30 days after sowing and it

*Department of Vegetable Crops, BCKV, Mohanpur, Nadia, West Bengal.

Table 1. Effect of integrated weed management on yield components, yield and economics of baby corn (Pooled data of 2 year)

Treatment	Cobs/ plant	Cob weight with husk (g)	Cob weight without husk(g)	Cob yield with husk (kg ha ⁻¹)	Baby corn yield (kg ha ⁻¹)	Green fodder yield (kg ha ⁻¹)	Cost of cultivation (kg ha ⁻¹)	Gross return (kg ha ⁻¹)	Net return (kg ha ⁻¹)	Benefit cost ratio
W ₁ - Weedy check	1.43	25.73	5.74	4576	1098	32281	13162	35520	22358	1.70
W ₂ - One hand weeding at 20 DAS	1.90	31.71	6.39	8509	1486	42224	18852	47706	28854	1.53
W ₃ - Two hand weeding at 20 DAS & 40 DAS	2.45	38.15	7.28	10134	1907	47013	22650	59428	36778	1.62
W ₄ - Pre-emergence atrazone @ 1 kg ai ha ⁻¹	2.01	32.09	6.58	8681	1576	43129	15262	50182	34920	2.29
W ₅ - Pre-emergence atrazine 1 kg ai ha ⁻¹ + one hand weeding 30 DAS	2.51	39.06	7.64	10337	1688	47507	18250	61577	43327	2.37
W ₆ - Pre-emergence alachlor @ 1.5 kg ai ha ⁻¹	1.98	31.893	6.41	8535	1515	42895	15857	48599	32742	2.06
W ₇ - Pre-emergence alachlor @ 1.5 kg ai ha ⁻¹ + one hand weeding 30 DAS	2.13	35.15	6.73	8843	1634	45712	18746	52278	33530	1.79
C.D. (0.05)	0.25	3.25	0.48	376.7	123.6	1095.4	-	1682.3	1274.8	0.18

was at par with the treatment W₃ which received two hand weeding 20 and 40 days after sowing. All the yield components were lowest in weedy check (W₁) treatment. Other than these three treatments all yield components were at par with each other. Similar results also observed by Prasad *et al.* (1990) and Sinha *et al.* (2000). As expected, the results indicated that cob yield with husk, baby corn yield and green fodder yield were higher with treatment which received preemergence atrazine @ 1 kg ai ha⁻¹ + one hand weeding 30 DAS which was at par with treatment that received two hand weeding 20 and 40 DAS and lowest was recorded with weedy check treatment. Similar results also reported by Prasad *et al.* (1990) and Talatala Sinco and Ranchez (1990).

Economics

Gross return, net return and benefit cost ratio were significantly influenced by the weed control treatments. Application of atrazine @ 1 kg ai ha⁻¹ + one hand weeding at 30 DAS (W₅) had maximum gross return, being (73%) more than the crop raised in weedy check. Consequently, highest return was recorded with the treatment received atrazine @ 1 kg ai ha⁻¹ + one hand weeding at 30 DAS which was significantly superior over all other treatments and lowest was with in weedy check (W₁). Angiras and Singh (1991) and Sharma *et al.* (1998) also observed that application of pre-emergence herbicides followed by one hand weeding gave highest net return than only manual and chemical weed control in maize.

The higher benefit : cost ratio was noticed in treatment which received @ 1 kg ai ha⁻¹ + one hand weedy 30 DAS followed by pre-emergence application of atrazine @ 1 kg ai ha⁻¹ (W₄).

REFERENCES

- Angiras, N.N. and Singh, C.M. 1991. Economics analysis of integrated weed management in Maize. *Indian J. Weed Sci.*, **21** (3-4) : 29-36.
- Prasad, T.V.R., Dwarakanath, N. Narasimaha, N. and Krishnamurthy, K. 1990. Integrated weed management in maize - effect on weeds, crop growth and yield. *Mysore J. Agril. Sci.*, **24**(1) : 39-44.
- Sharma Vinod, Thankur, D.R. and Sharma, V. 1998. Integrated weed management in maize under mid-hill conditions of north-western Himalayas. *Indian J. Weed Sci.*, **30** (3-4) : 158-162.
- Sinha, S.P., Prasad, S.M. and Singh, S.J. 2000. Effect of integrated weed management on growth yield attributes and yield of winter maize. *J. Applied Biology*, **10**(2) : 158-162.
- Talatala Sinco, R.L. and Ranchez, C.V. 1990. Integrated weed control approach in corn. *Philippine J. Weed Sci.*, **17** : 33-38.

EFFICACY OF DIFFERENT FUNGICIDES ON THE INCIDENCE OF YELLOW RUST (PUCCINIA STRIIFORMIS) ON WHEAT UNDER COLD ARID CONDITIONS OF LADAKH

V.K. YADAV*, M.A. WANI, H.V. SINGH AND M.S. MIR

Regional Agricultural Research Sub Station
Sher-E-Kashmir University of Agricultural Sciences and Technology
(Kashmir), Kargil-194 103 (Jammu and Kashmir)

ABSTRACT

An experiment with four fungicides viz. Mancozeb, Triadimefon, Carbendazim and Oxycarboxin was conducted for the management of yellow rust of wheat. All the fungicides were applied as seed treatment, foliar spray and seed treatment + foliar spray in different doses and on different stage of crop. The fungicide Triadimefon 2.5 g/kg seed as seed treatment water as foliar spray at heading stage of the crop was found most effective and gave 10 PDI and 29.45 q/ha grain yield followed by Oxycarboxin as seed treatment + foliar spray, the PDI and yield were recorded 15 and 27.18 q/ha, respectively. Carbendazim performed better in seed treatment, foliar spray and seed treatment + foliar spray, the PDI and yield were 66.66 and 14.20 q/ha, 35.00 and 23.26 q/ha and 20.00 and 26.63 q/ha, respectively.

Key words : Yellow rust, wheat, fungicides, cold arid, Ladakh.

Wheat is a summer crop of cold arid zone, grown between March to September. It is second major crop of this region, first begin barley. However with the change in food habits, area under wheat is steadily increasing. Wheat cultivation is restricted in the region due to short cropping season, varietal diversities and harsh conditions of high altitude (Sharma *et al.* 1999). Wheat, in the region is subjected to attack of several pathogens causing diseases in standing crop which results in yield reduction. Among three rusts, mostly two type of rusts occur in the region viz., yellow and brown rust. The infection by *P. striiformis* west. (yellow rust) is common on susceptible cultivars through out the region. Keeping the above points in view, different fungicides were evaluated against *P. striiformis* West. on wheat under cold arid conditions of Ladakh.

MATERIALS AND METHODS

The present experiment was conducted at Regional Agricultural Research Sub-station Kargil

*Present address : College of Forestry & Hill Agriculture, G.B. Pant University of Agril & Tech., Hill Campus, Ranichauri-249199, Tehri Garhwal, Uttranchal.

during 2001 to 2003 in randomized block design using 3 replications, with 3 m × 1.5 m plot size. The seeds of highly susceptible local wheat variety were sown @ 250 kg/ha maintaining 23 cm row to row spacing. The field was allowed for natural occurrence of the yellow rust pathogen. The recommended agronomical practices were followed during the experiment. Thirteen treatments combinations were made viz. seed treatment with Mancozeb, Triadimefon, Carbendazim, Oxycarboxin @ 2.5 g/kg seed, foliar spray of Mancozeb (0.25%), Triadimefon, Carbendazim, Oxycarboxin (0.1%) and seed treatment plus spray of Mancozeb, Triadimefon, Carbendazim, Oxycarboxin spray along with a control plot. In case of seed treatment, fungicides were mixed well with the seed before sowing and for foliar spray fungicides were suspended in water according to requirement. First spray was done on appearance of disease and second spray after a fortnight of first spray. In case of seed treatment + foliar spray, the fungicides were sprayed once at heading stage of the crop. The data regarding PDI were recorded after a week of final spray. The grain yield was recorded plot wise after harvest of the crop. The data were subjected to standard statistical analysis.

RESULTS AND DISCUSSION

Experimental results revealed that all the treatments were significantly effective against yellow rust disease except seed treatment with Mancozeb. The minimum PDI (10.00) was recorded in seed treatment + foliar spray of Triadimefon followed by seed treatment and foliar spray of Oxycarboxin (15.00 PDI) and Carbendazim (20.00 PDI), these three fungicidal treatments also produced grain yield of 29.45, 27.18 and 26.63 q/ha, respectively. This was similar with the findings of Chirsi and Frank (1989) who reported higher efficiency of combined application of seed treatment and foliar application of triadimenol in reducing the severity of leaf rust in winter wheat cultivars. However, foliar spray of Triadimefon showed only 18.33 PDI with grain yield of 25.33 q/ha and was followed by foliar spray of Oxycarboxin (54.33 PDI) and Carbendazim (35.00 PDI) with grain yield of 24.73 q/ha and 23.26 q/ha, respectively. In case of seed treatment, all the fungicides did not show good results in respect to reducing disease infection as well as in increasing grain yield. Maximum PDI of 90.00

and lowest grain yield of 11.14 q/ha was recorded for control plots. The results also revealed that the increase in disease infection caused reduction in grain yield. Goulart (1999) reported that the best disease control was obtained by Triadimenol which gave 67% control when tested against *P. recondita*. It is also reported that the fungicide Triadimenfon and its metabolite Triadimenol reduced the infection of yellow rust of wheat and prolonged the latent infection period (Qin Qing Ming *et al.*, 1999). The present results are in support of these earlier findings.

In case of seed treatment with Mancozeb, Triadimefon, Carbendazim and Oxycarboxin, the infection and grain yield were recorded 85.00 PDI and 15.75 q/ha, 56.66 PDI and 18.10 q/ha, 66.66 PDI and 14.20 q/ha and 58.33 PDI and 16.10 q/ha, respectively gave poor performance. This may be due to the secondary spread of the inoculum on the crop. Marshall (1988) observed that fungicide Triadimefon when applied at flag leaf emergence, gave good results in reducing yellow rust infestation and increased the yield by 46% as compared to untreated plots. Finally

Table 1. Efficacy of different fungicides on the incidence of yellow rust disease and grain yield of wheat

S.No.	Treatments	Dosage	PDI*	Grain yield (q/ha*)
1	Mancozeb (ST)	2.5 g/kg seed	85.00 (67.21)	15.75
2	Triadimefon (ST)	2.5 g/kg seed	56.56 (48.82)	18.10
3	Carbendazim (ST)	2.5 g/kg seed	66.66 (54.73)	14.20
4	Oxycarboxin (ST)	2.5 g/kg seed	58.33 (49.79)	16.10
5	Mancozeb (FS)	2.5 g/kg seed	61.66 (51.74)	13.10
6	Triadimefon (FS)	1 g/l water	18.33 (25.34)	25.33
7	Carbendazim (FS)	1 g/l water	35.00 (36.27)	23.26
8	Oxycarboxin (FS)	1 g/l water	25.00 (30.00)	24.73
9	Mancozeb (ST+FS)	2.5 g/kg seed+1 g/l water	65.00 (53.72)	22.09
10	Triadimefon (ST + FS)	2.5 g/kg seed+1 g/l water	10.00 (18.43)	29.45
11	Carbendazim (ST + FS)	2.5 g/kg seed+1 g/l water	20.00 (26.56)	26.63
12	Oxycarboxin (ST + FS)	2.5 g/kg seed+1 g/l water	15.00 (22.78)	27.18
13	Control	—	90.00 (71.56)	11.14
C.D. (P=0.05)			13.54	4.42

*Pooled mean of three years.

Figures in parentheses are arc sin transformed values.

on the basis of present findings it is concluded that the fungicide Triadimefon followed by Oxycarboxin and Carbendazim if used as seed treatment + foliar spray will be effective against yellow rust disease caused by *P. striiformis* under cold arid conditions of Ladakh.

ACKNOWLEDGMENT

This study was taken as a part of the sub-project "PHA-27" funded by the National Agricultural Technology Project, Indian Council of Agricultural Research. The financial help is thankfully acknowledged.

REFERENCES

- Chirsi, B.J. and Frank, J.A. 1989. *Plant Disease*, 73 : 148-150.
- Goulard, A.C.P. 1999. *Summa Phytopathologica*, 25 : 165-168.
- Marshall, D. 1988. *Plant Disease*, 72 : 239-241.
- Qin Qing Ming, Qin Yin Ping, Xiao Yue Tan and Wang Yi. 1999. *Acta Phytopathologica*, 26 (3) : 243-249.
- Sharma, J.P., Mir, A.A. and Yadav, V.K. 1999. *Indian Wheat Newsletter*, 5 : 2-3.



STABILITY ANALYSIS FOR PERFORMANCE OF RAINFED BREAD WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES

R.B. YADAW* AND H.B. CHOUDHARY**

*Nepal Agricultural Research Council, Kathmandu, Nepal

**Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Thirty genotypes of bread wheat were evaluated under four artificially created environments i.e. timely sown rainfed, late sown rainfed, timely sown irrigated and late sown irrigated for stability parameters in respect of grain yield, its components and quality characters. Pooled analysis of variance for stability has shown significant differences among genotypes for $G \times E$ interaction for grain yields, its components and quality characters. The environment (linear) was found significant with difference for all studied characters, whereas $G \times E$ (linear) was significant for number of grains per spike and sedimentation value. The genotypes in different groups of combination showed stability for grain yield q/ha, 1000 grain weight, tiller per meter, as well as for protein percentage and sedimentation value.

Key words : Bread wheat, $G \times E$ interaction, stability, protein percentage.

Wheat (*Triticum aestivum* L.) is second most important crop in India after rice. The major area under cultivation is of semi dwarf genotypes under intensive agriculture of timely sowing irrigated conditions. However, the wheat in some part of the country is being cultivated under rainfed conditions. This covers an area nearly 8.4 million hectares and its productivity has remained low and static. Preference for cultivation of wheat under rainfed condition as well as under moisture stress often depends up on the choice of farmers and consumers, because the wheat produced under rainfed as most preferred. Enhancement of protein level alongwith sedimentation value of flour for nutrition and food processing is also important as genotypes fetch higher price in national and international markets. For sustainable crop production under rainfed and moisture stress condition, it is required to have stable high yielding genotypes which could have minimum loss of grain yield and its quality.

MATERIALS AND METHODS

Bread wheat genotypes including seventeen test entries 8 of rainfed and 5 of late sown irrigated conditions were grown in randomized block design with three replications in four

artificially created environments i.e. timely sown rainfed, late sown rainfed, timely sown irrigated and late sown irrigated during 2002-2003 at the Indian Agricultural Research Institute, New Delhi. Stability analysis was carried out using Eberhart and Russell (1966) Model.

RESULTS AND DISCUSSION

Highly significant differences were found among the genotypes for all the studied characters. However, significant variability was not found among the tested genotypes in respect of protein percentage. The mean square due to genotype $\times$ environment interaction were highly significant for all the characters, when tested against both pooled error and pooled deviation. Further partitioning of the component environments $G \times E$ interaction was found to be significant for stability of tiller number per meter whereas the environment and $G \times E$ interactions were not significant for rest of tested characters. The environment (linear) for all studied characters were significant. $G \times E$ interactions (linear) were significant for number of grains per spike and sedimentation value when tested against pooled deviation. Pooled deviation significantly differed with respect to all characters against pooled error.

It is evident (Table 1) that test genotype Indore-1, Indore-9, HD-2865 and HDR-77 had significant regression coefficient (b_i) and highly significant deviation from regression (S^2_{di}) with mean values of grain yield q/ha 26.57, 34.43 and 25.82, indicating its instability and specifically suitability for favourable environments.

The genotypes and their mean grain yield as HD-2865 (34.97 q/ha), HD-2868 (32.83 q/ha) and HD-2781 (31.62 q/ha) were found with higher mean value for grain yield q/ha and with non significant regression coefficient (b_i) and deviation from regression (S^2_{di}) showing them as stable and suited to unfavourable environments. The genotypes; L-1705, Indore-6, RS-839, RS-845, PBW-175 and C-306 possessed slightly lower mean values of grain yield q/ha but non significant regression coefficient (b_i) and deviation from regression (S^2_{di}) indicating these were stable and adapted to unfavourable environments.

For grains per spike, RS-839 (36.17), RS-840 (30.50), HD-2781 (38.08), HD-2865 (38.67), HD-2866 (37.42), HD-2837 (37.75), HD-2285 (41.42) and K-8027 (38.58) were found with higher and non significant regression co-efficient and non significant deviation from regression, indicating their stability across the environments. Although the mean values of UP-2338 and HW-2045 were lower and did not differ significantly from unit b_i (regression coefficient) as well as S^2_{di} (deviation from regression), these genotypes were stable for this characters. The genotypes; IB2K-61, L-814, L-1705, Indore-1, HD-2285, HD-2868, HDR-77, NI-5439, PBW-373, K-8027, UP-2338, C-306 and HW-2045 had non significant regression coefficient approaching unity. It could not be regarded as widely adapted due to the significant difference deviation from regression for spikelets per spike. It is apparent from table that for 1000 grain weight out of 30 genotypes, 8 genotypes were having non significant b_i value and non significant S^2_{di} and hence, were stable and suitable to unfavourable environments. Such observation have been supported by Latasara and Paroda (1980), Bullar et al. (1983), Mishra et al. (1991) and Khanna-Chopra (1999). Some genotypes with such behaviour could be identified. This genotypes highly stable for yield

can be obtained if their component traits are also stable. For protein percentage, all genotypes had non significant regression co-efficient except only one genotype HD-2815. But significant deviation from regression was observed for Indore-5, RS-845, HD-2781 and HD-2815 which were unstable and suitable for favourable environments. However, it is apparent that majority of genotypes showed non significant b_i (regression co-efficient) and non significant S^2_{di} (deviation from regression) and hence, were stable and suitable for unfavourable environments. Generally the sedimentation value ranging between 20-40 denotes all purposes bread wheat. Among them, Indore-1, Indore-6, Indore-9 HD 2866, HD-2285, HDR-77 were having mean values of sedimentation 41.42, 41.83, 37.33, 41.75 and 41.17 respectively with non-significant regression co-efficient (b_i) approaching zero. All these genotypes were stable and suited to wide range of environments.

These findings are in agreement with those of Baenziger *et al.* (2001), Matus-cadiz *et al.* (2003), Maloo *et al.* (1999) who observed behavior of wheat genotypes in respect of quality and grain yield.

Stability performance of HD-2865, HD-2868 and HD-2781 having higher mean values for grain yield q/ha and highly stable across the environments has been presented Table 1. The genotypes HD-2781, C-306, PBW-175 and Indore-1 had average mean values and were stable for tiller number per meter over environments. For grains per spike, HD-2865, HD-2866, HD-2781 and HD-2285 were found higher mean value and highly stable. HD-2781 showed highly stable with more number of spikelets per spike. Whereas, Indore-6 and PBW-175 were found highly stable with lower number of spikelets per spike. HD-2868 had higher 1000 grain weight with stable performance. For protein percentage, majority of genotypes were highly stable across the environments. Since the protein percentage ranged very closely between 13.03-14.21 per cent for all the genotypes, environmental impact on the trait was minimum. In case of sedimentation values HD-2285, Indore-6, Indore-9 and HD-2866 had highly stable value which could be utilized all purposes bread wheat.

Table 1. Stability parameters of bread wheat genotypes for yield its component and quality characters

S.N.	Genotypes	Grain yield (q/ha)			No. of tillers/m			No. of grains/spike			No. spikelets/spike		
		Mean	bi	S ² di	Mean	bi	S ² di	Mean	bi	S ² di	Mean	bi	S ² di
1	IB2K-61	22.50	1.32	119.43**	127.00	-1.70	908.39	36.92	2.63	76.43**	17.00	3.38	8.66**
2	IB2K-99	25.16	1.84	33.47**	106.00	-1.47	2533.56**	39.42	3.70*	18.63**	17.08	1.58	0.22
3	L-814	24.63	1.08	69.45**	120.00	1.49	1522.23**	35.92	1.23	10.00**	16.33	2.04	7.43**
4	L-1705	24.18	1.40	4.16	112.00	0.69	30.68*	33.92	3.11**	46.25**	14.25	0.66	25.40**
5	Indore-1	26.57	1.90*	9.05	98.00	1.15	10.06	32.50	1.79	76.76**	15.58	3.05	6.12**
6	Indore-5	23.51	0.74	13.38**	101.00	-0.73	373.29**	36.08	0.06	27.25*	15.92	1.79	-0.14
7	Indore-6	23.89	0.78	-1.93	120.00	1.01	276.96**	35.17	-0.56	13.50*	14.08	-2.37	0.83
8	Indore-9	25.83	1.92	99.71**	99.00	1.49	1274.58**	33.33	-3.40*	28.88*	14.92	-0.80	1.63
9	RS-839	21.35	0.09	5.55	129.00	-0.15	1217.51**	36.17	2.24	-1.12	18.83	2.01	-0.24
10	RS-840	25.37	1.10	30.14**	110.42	0.91	3137*	36.50	1.67	-0.28	16.58	1.03	0.85
11	RS-843	23.74	0.66	12.86**	120.00	1.09	202.60**	30.08	0.80	43.85**	12.42	-1.08	1.80
12	RS-845	24.49	1.14	4.60	129.00	0.60	289.69**	34.83	4.74**	23.64**	16.83	2.94	8.05**
13	HD-2865	34.43	1.95**	7.32**	143.00	-1.22	179.39*	38.67	1.92	2.79	18.00	0.01	3.03**
14	HD-2866	34.97	1.13	-1.60	158.00	-0.67	131.00**	37.42	0.54	-1.86	17.33	0.86	2.42
15	HD-2837	25.64	1.81	65.66**	109.00	1.66	305.11**	37.75	-0.12	-0.58	17.25	1.07	-0.30
16	HD-2815	27.15	0.86	27.44**	106.00	0.97	-29.65*	34.75	1.03	26.82**	14.33	0.70	0.11
17	HD-2868	32.83	1.03	3.67	132.00	2.01	64.74**	40.83	2.32	30.99**	18.42	0.57	5.24**
18	HD-2781	31.62	1.02	2.14	111.00	0.03	-7.53	38.08	2.04	-2.12	17.42	-0.81	0.84
19	DL-153-2	20.79	-0.39	9.28**	109.00	0.91	74.43**	34.42	0.25	2530**	15.42	-2.60	-0.10
20	HDR-77	25.82	1.87*	32.53**	136.00	3.05*	1157.29**	31.08	-1.97	1557**	14.08	-0.17	2.50*
21	NI-5439	19.57	-0.82	11.58**	96.00	0.35	108.80**	33.17	4.20	8.71**	15.17	3.98	2.54*
22	HI-1500	22.87	0.82	38.92**	106.00	2.42	1425.34**	36.17	1.23	25.56**	17.58	2.02	-0.15
23	K-8027	23.15	-0.40	72.82**	111.00	2.87*	778.96**	38.58	-2.30*	23.74**	19.03	-0.71	-2.70*
24	PBW-175	21.21	1.28	2.23	89.00	0.80	8.33	30.08	0.35	15.45**	13.75	2.51	1.90
25	C-306	20.86	1.18	4.48	90.00	0.60	6.44	29.33	0.35	10.06**	13.42	1.65	4.88**
26	HW-2045	24.98	0.76	39.47**	106.00	2.44	292.87**	37.08	-2.57	-1.85	16.17	0.37	8.01**
27	DL-788-2	23.62	0.67	12.23**	109.00	2.32	29.58*	37.00	1.03	7.14*	18.67	2.36	1.70
28	HD-2285	29.58	1.49	56.95**	129.00	2.79*	587.60**	41.42	0.87	0.42	19.00	1.07	5.77**
29	PBW-337	23.68	1.50	49.04**	109.00	1.40	1768.11**	35.58	3.68*	23.74**	16.67	1.93	2.43*
30	UP-2338	17.86	0.24	15.30**	90.00	1.35	85.48**	30.17	-0.83	2.96	14.67	2.69	10.71**
	Pop. Mean	25.062			114.00			35.41			16.21		
	SEm±bi	0.91			1.315			1.45			2.02		
	SEm±t	3.213			13.56			2.653			1.19		

contd...

Table 1. contd...

S.N.	Genotypes	1000-grain wet. (g)				Protein (%)				Sedimentation value			
		Mean	bi	S ² di		Mean	bi	S ² di		Mean	bi	S ² di	
1	IB2K-61	39.32	0.18	4.70*		13.39	0.27	0.00		47.92	1.23*	12.89**	
2	IB2K-99	40.94	2.56*	21.68**		13.70	0.65	0.30		41.00	-0.31	9.03**	
3	L-814	36.69	1.63	20.34**		13.29	0.12	0.02		47.42	1.59**	30.02**	
4	L-1705	35.28	1.36	-0.20		13.60	1.09	0.41		58.00	2.10**	-0.20	
5	Indore-1	37.86	-0.84	25.94**		13.10	0.75	0.02		41.42	-0.21	-1.20	
6	Indore-5	31.33	1.22	6.62**		13.55	2.24	0.70*		50.83	0.11	-1.13	
7	Indore-6	33.00	-1.44	18.03**		13.45	0.87	0.07		41.83	-0.23	3.28	
8	Indore-9	32.85	1.97	0.60		13.37	1.35	0.45		37.33	-0.54	2.57	
9	RS-839	35.57	1.82	-0.58		13.03	0.90	0.13		35.83	-1.04*	5.20**	
10	RS-840	37.15	2.30*	-0.61		13.50	0.26	0.04		44.33	1.19**	20.91**	
11	RS-843	40.70	1.98	16.18**		13.86	0.76	0.14		39.33	0.98*	3.96*	
12	RS-845	39.40	3.42*	6.96**		14.08	3.05	1.34		48.75	3.02**	20.90**	
13	HD-2865	39.72	1.88	11.36**		13.99	0.55	0.13		48.92	2.6*9*	2.70	
14	HD-2866	38.72	-0.09	34.40**		13.74	0.34	0.14		40.92	0.08	0.39	
15	HD-2837	33.33	-1.54	29.58**		13.59	0.91	0.05		53.17	2.42**	2.77	
16	HD-2815	39.02	1.31	0.50		13.82	5.17**	2.08**		44.33	1.87**	6.49**	
17	HD-2868	38.97	0.81	-0.83		13.55	0.55	0.15		41.17	1.09*	26.49**	
18	HD-2781	37.75	2.78*	1.92		13.69	2.37	1.00**		47.67	2.95**	9.74**	
19	DL-153-2	29.30	0.17	-0.19		13.42	1.31	0.10		54.67	2.63**	4.17*	
20	HDR-77	33.72	0.47	42.19**		13.39	0.44	-0.03		41.17	-0.01	-0.78	
21	NI-5439	35.73	1.70	26.65**		13.34	0.74	0.03		52.50	2.58**	4.34*	
22	HI-1500	42.57	0.21	27.14**		13.41	0.47	-0.02		43.42	0.15	14.05**	
23	K-8027	36.08	1.94	46.99**		13.58	0.82	0.19		38.42	-0.03	6.96**	
24	PBW-175	28.51	0.58	-0.33		14.04	0.34	0.12		50.58	2.48*	2.80	
25	C-306	29.06	0.28	6.57**		14.08	0.05	-0.10		37.58	-0.13	5.83**	
26	HW-2045	33.36	1.48	19.07**		14.21	0.06	-0.16		38.67	0.01	31.28**	
27	DL-788-2	33.28	0.97	6.93**		13.04	0.86	0.36		41.75	-0.25	3.56	
28	HD-2285	32.33	-0.54	2.95		14.07	2.93	0.06		42.92	1.92**	5.24**	
29	PBW-337	36.08	1.94	46.99**		13.58	0.82	0.19		35.83	1.08*	-1.64	
30	UP-2338	33.10	0.18	7.43**		14.02	1.15	0.20		42.17	0.59	5.12**	
Pop. Mean		35.67				13.61				44.33			
SEm±bi		1.032				1.58				0.48			
SEm±t		2.28				0.32				1.805			

* Significant at 5% level, ** Significant at 1% level

REFERENCES

- Baenziger, P.S., R.L. Clements, M.S. McIntosh, W.T. Yamazaki, T.M. Startling, D.J. Sammons and J.W. Johnson, 1985. *Crop Sci.*, **25** : 5-8.
- Bassett, L.M., Allan, R.E. and Rubenthaler, G.L. 1989. *Crop Sci.*, **25** : 5-8.
- Bhullar, G.S., Singh, R. and Gill, K.S. 1983. *Indian J. Genet.*, **43** : 246-257.
- Jatasara, D.S. and Paroda, R.S. 1980. *Indian J. Genet.*, **43** : 246-257.
- Khanna Chopra, R. and Viswanathan, C. 1999. *Euphytica*, **106** : 169-180.
- Maloo, S.R., Saini, D.P., Pandiya, N.K. and Paliwal, R.V. 1999. *Agricultural Science Digest (Karnal)*, **19** (2) : 140-142.
- Matus-Cadiz, M.A., Hucl, P., Perron, C.E. and Tyler, R.T. 2003. *Crop Sci.*, **43** : 219-226.
- Mishra, S.C., Bhagwat, M.D. Dixit, R.N., Rao, V.S.P. and Patil, V.P. 1991. *Indian J. Agric. Sci.*, **61** : 7-10.
- Peterson, C.J., Sheltan, R.P., Martin, T.J., Sears, R.G., Williams, E. and Graybosch, R.A. 2001. *Euphytica*, **199** : 101-106.

EFFECT OF FOLIAR APPLICATION OF DIFFERENT SOURCES OF ZN ON THE CHANGES IN ZN CONTENT, UPTAKE AND YIELD OF RICE (*ORYZA SATIVA* L.)

D.K. DAS, TANMOY KARAK AND DEBTANU MAITI

Department of Agricultural Chemistry and Soil Science, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia-741252, West Bengal

ABSTRACT

The results show that the amount of Zn content in and uptake by grain (17.6 mg kg^{-1} and 85.6 g ha^{-1}) and straw (17.0 mg kg^{-1} and 123.4 g ha^{-1}) have been found to be increased significantly in the treatment F_3 where twice foliar applications of Zn as Zn-EDTA@0.05% was made with the simultaneous highest increase in grain (4.9 t ha^{-1}) and straw (7.2 t ha^{-1}), respectively, as compared to foliar applications of same levels of Zn as ZnSO_4 being 16.0 and 38.8 per cent increase in the yield of grain and straw respectively over that of the control, no application of Zn. The results also clearly indicated that the yield of both grain and straw due to foliar application of Zn either in the form of Zn-EDTA or ZnSO_4 were significantly positively correlated with the Zn uptake by grain and straw, being more significant with Zn-EDTA application. The grain yield vs. Zn content in grain showed a significant positive correlation ($r=0.82^{**}$) suggesting an important role of Zn towards contributing the yield of rice.

Key words : Lowland soil conditions, yield, rice, sources of Zn.

Zinc is one of the important essential micronutrients required for growth, development and yield of most crops especially rice grown in lowland conditions. As much as around 40% of soil samples analysed throughout all districts of West Bengal have been found to be deficient in Zn. The problem seems to be more acute for rice as about 50% of the total rice area found to be severely affected by Zn deficiency since rice is grown mostly on submerged soils where availability of Zn is affected adversely. Zinc plays an important role in different plant metabolism process like development of cell wall, respiration, photosynthesis and other biochemical functions etc. Zinc is an indispensable micronutrient for proper plant growth and development (Das and Saha, 1999). Singh and Abrol, 1986 reported that, on an average 50% of the Indian soils are deficient in zinc.

It is evident that the Zn deficiency is correlated through the application of an inorganic salt, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, which on application to the soil interacts with various soil components like clay, organic matter, sesquioxides etc. fixing or forming its insoluble

complexes which ultimately decreased the availability of Zn in soils vis-a-vis uptake by the plants. Moreover, the application of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ may have some harmful effects on plant leaves affecting absorption of Zn by plants. Another sources are the chelated forms of Zn such as Zn-EDTA, Zn-DTPA etc. that are able to supply substantial amount of Zn to the plant without interaction with various soil components. Chelated-Zn in the form of Zn-EDTA is a free flowing crystalline powder salt. It is guaranteed to contain a minimum 12 per cent Zn by weight. On an equivalent Zn-basis, chelated-Zn is at least five times more effective than inorganic Zn-salts although chelated-Zn is most costly (Katyal and Randhawa, 1983). Keeping these in view, the present research programme was undertaken to study the effect of foliar application of different sources of Zn on the content, uptake of Zn and yield of rice.

MATERIALS AND METHODS

Field experiments

Two field experiments on rice (cv. IET - 4094) were conducted in rabi seasons during 1999-2000 and 2000-2001 in the Bidhan Chandra Krishi

Viswavidyalaya Farm, Kalyani, Nadia, West Bengal. The soil of the experimental plot was silty clay loam (Aeric Haplaquept) whose relevant physico-chemical characteristics are pH (1:2.5), 6.80; organic C (g kg^{-1}), 5.34; CEC ($\text{c mol (p}^+\text{) kg}^{-1}$), 14.32 and DTPA extractable Zn (mg kg^{-1}), 0.51. The DTPA solution (0.005 M at pH 7.5) was used to extract the available pool of zinc from soils following the method as described by Lindsay and Norvell (1978). The size of the experimental plot was 5m $\times$ 4m. There were seven treatments and replicated thrice in a randomized block design (RBD). All the plots were received recommended level of N, P and K (60:30:30) fertilizers. The treatments were as follows :

F_0 = Control (no application of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ or Zn - EDTA); F_1 = 0.05% of Zn as Zn - EDTA; F_2 = 0.10% of Zn as Zn-EDTA; F_3 = 0.10% of Zn as Zn-EDTA (application of Zn as Zn-EDTA in two equal splits first at grand tillering stage and second at panicle initiation or PI stage); F_4 = 0.20% of Zn as Zn-EDTA; F_5 = 0.05% of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$; F_6 = 0.10% of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$; F_7 = 0.10% of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (application of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ in two equal splits first at grand tillering stage and second at panicle initiation or PI stage) and F_8 = 0.20% of Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$.

Periodic collection of plant samples were digested with a ternary acid mixture (HNO_3 ; HClO_4 ; H_2SO_4 : : 10:4:1; Jackson, 1973) after drying the samples in a hot air oven at a temperature of $65 \pm 5^\circ\text{C}$ (Jackson, 1973). Digested plant samples were then ready for the determination of Zn with the help of Atomic Absorption Spectrophotometer (Perkin Elmer; Model - Analyst 100). All the plots of both experiments relating to foliar application were received a recommended basal application of NPK fertilizers @ 100 : 60 : 60 kg, respectively.

RESULTS AND DISCUSSION

Zn content in dry matter of rice

The results (Table 1) show that the amount of Zn content in dry matter of rice significantly increases with the application of different sources and levels of Zn, being significantly highest with

the application of chelated form of Zn particularly at its split application. Although, the application of Zn in the form of ZnSO_4 increase the Zn content in dry matter as compared to control (F_0) where no application of Zn was made. However, the absolute increase in the Zn content in dry matter was recorded highest (9.54 mg kg^{-1}) in the treatment F_3 where Zn @ 0.05% in the form of Zn-EDTA was applied twice. The results further pointed out that the application of 0.05% Zn as foliar spray either in the form of ZnSO_4 or Zn-EDTA did not show any significant variation on the Zn content at 63 days of crop growth. Such relatively higher absorption of Zn due to foliar application of Zn-EDTA irrespective of its various modes of application might be due to the rapid rate of absorption caused by greater mobility of Zn when Zn is present in Zn-EDTA than that of the Zn when applied in the form of ZnSO_4 or Zn-EDTA did not show any significant variation on the Zn content at 63 days of crop growth. Such relatively higher absorption of Zn due to foliar application of Zn-EDTA irrespective of its various modes of application might be due to the rapid rate of absorption caused by greater mobility of Zn when Zn is present in Zn-EDTA than that of the Zn when applied in the form of ZnSO_4 . Comparing the mean effect of different treatments it was observed that the pattern of changes was in the following order : $F_3 > F_1 > F_2 > F_4 > F_6 > F_7 > F_5 > F_8 > F_0$.

The mean Zn content in rice dry matter was recorded highest in F_3 treatment which closely followed by F_1 , where 1% Zn as Zn-EDTA (two equal splits) and 0.05% Zn as Zn-EDTA was applied as foliar spray. The trend of changes in the Zn content of rice dry matter followed the same pattern.

Zn content and uptake by rice grain and straw

The amount of Zn content and uptake (Table 2) by both grain and straw was significantly highest in the treatment F_3 where foliar spray of Zn-EDTA twice @ 0.05% was applied. However, the trend of changes of Zn content in the grain and straw as follows : $F_3 > F_4 > F_7 > F_2 > F_1 > F_6 > F_8 > F_5 > F_0$. The mean content and uptake by both grain and straw during both years were also changed similarly.

Table 1. Effect of foliar application of different sources of zinc on the periodic changes in the Zn content in dry matter of rice (mean of two years)

Treatments	Zn content (mg kg ⁻¹)							
	Days after transplanting							
	14	21	28	35	42	49	56	63
F ₀	3.40	3.43	3.47	3.25	3.19	3.10	3.26	3.33
F ₁	9.26	9.32	9.36	9.21	9.11	9.26	9.34	9.42
F ₂	8.74	8.78	8.88	8.56	8.49	8.35	8.46	8.59
F ₃	9.26	9.32	9.36	9.21	9.11	9.46	9.52	9.54
F ₄	8.42	8.46	8.57	8.43	8.32	8.29	8.47	8.58
F ₅	7.23	7.64	7.69	7.25	7.18	7.10	7.36	7.42
F ₆	7.95	7.97	7.99	7.72	7.64	7.55	7.82	7.83
F ₇	7.23	7.64	7.69	7.25	7.18	7.82	7.88	7.88
F ₈	7.04	7.14	7.19	6.98	6.92	6.84	6.86	6.94
C.D. at 5%	0.415	0.084	0.084	0.304	0.111	0.133	0.079	0.106

Table 2. Effect of foliar application of different sources of Zn in grain and straw of rice (mean of two years)

Treatments	Zn content (mg kg ⁻¹)		Zn uptake (g ha ⁻¹)	
	Grain	Straw	Grain	Straw
F ₀	13.02	12.81	54.55	66.61
F ₁	16.61	16.44	74.91	106.04
F ₂	16.82	16.58	76.87	109.93
F ₃	17.62	17.04	85.63	123.37
F ₄	17.02	16.85	78.97	114.92
F ₅	14.14	14.02	61.37	83.98
F ₆	15.45	15.02	69.22	94.93
F ₇	16.86	16.69	77.22	111.66
F ₈	15.02	14.76	66.39	90.63
C.D. at 5%	0.083	0.095	0.096	0.095

Yield of rice

The results (Table 3) show that the yield of grain and straw were recorded highest (4.86 t ha⁻¹ for grain and 7.24 t ha⁻¹ for straw) in the treatment F₃ where two times foliar spray with Zn-EDTA @ 0.05% Zn was applied, whereas the application of foliar spray twice with ZnSO₄ @ 0.05% Zn recorded the yield of grain (4.58 t ha⁻¹) and straw (6.69 t ha⁻¹). It is suggested that the use efficiency of applied Zn in the form of Zn-EDTA has been proved always higher in relation to Zn content in soils and plants reflecting higher increase in yield of both grain and straw as compared to Zn application as ZnSO₄. The per cent increase (Table 3) also recorded highest for grain (16.09%) and straw (38.81%) in the

treatment F₃ over control, while that of the same increase was only 9.30 and 28.63% in the ZnSO₄ treatment over control, respectively.

The correlation studies (Table 4) revealed that the yield of both grain and straw due to foliar application of Zn were significantly positively correlated with Zn content and uptake by grain and straw. The grain yield vs Zn content in grain showed a significant positive correlation ($r = 0.82^{**}$) while that of the straw yield showed a significant positive correlation with Zn content ($r = 0.95^{**}$) and uptake by straw ($r = 0.98^{**}$). However, from the correlation studies it may be concluded that the amount of Zn content in both grain and straw was considered as most

Table 3. Effect of foliar application of different sources of Zn on the yield and percent increase of grain and straw (mean of two years)

Treatments	Yield (t ha ⁻¹)		Per cent yield increase over control	
	Grain	Straw	Grain	Straw
F ₀	4.19	5.20	-	-
F ₁	4.51	6.54	7.75	24.59
F ₂	4.57	6.63	8.82	27.09
F ₃	4.86	7.24	16.09	38.81
F ₄	4.64	6.82	10.85	31.41
F ₅	4.34	5.99	3.34	14.60
F ₆	4.48	6.32	6.67	21.33
F ₇	4.58	6.69	9.30	28.63
F ₈	4.42	6.14	5.48	18.16
C.D. at 5%	0.22	0.10	-	-

Table 4. Regression equations and correlation coefficient (r) between grain yield vs Zn content in grains; grain yield vs Zn uptake by grain; straw yield vs Zn content in straw and straw yield vs Zn uptake by straw (mean of two years)

Parameters	Regression equation	Correlation coefficient
Grain yield vs Zn content in grain	$Y = 0.117 X + 2.68$	0.820**
Grain yield vs Zn uptake in grain	$Y = 0.010 X + 3.48$	0.840**
Grain yield vs Zn content in straw	$Y = 0.370 X + 0.63$	0.950**
Grain yield vs Zn uptake in straw	$Y = 0.059 X + 2.17$	0.980**

important towards contributing the yield of both grain and straw.

The mean yield of grain and straw was also recorded highest in the F₃ treatment (spraying with Zn as Zn-EDTA twice @ 0.5%) and F₇ treatment (spraying with Zn as ZnSO₄ twice @ 0.5%). Comparing the results of different sources

of Zn it was observed that the yield of both grain and straw in both the years were recorded always higher with the application of Zn-EDTA than that of ZnSO₄. However, the yield of both grain (4.86 t ha⁻¹) and straw (7.24 t ha⁻¹) were recorded highest in the treatment F₃ where 0.05% Zn as Zn-EDTA was applied twice as foliar spray.

REFERENCES

- Das, D.K. and Saha, D. 1999. In : Micronutrient Research in Soils and Crops of West Bengal; Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.
- Jackson, M.L., 1973. Soil Chemical Analysis. Prentice Hall of India (P) Ltd., New Delhi.
- Katyal, J.C. and Randhawa, N.R. 1983. Micronutrients. *FAO Fertilizer and Plant Nutrition Bulletin*, 7: FAO, Rome, Italy.
- Lindsay, W.L. and Norvell, W.A. 1978. *Soil Sci. Soc. Am. J.*, 42: 421-428.
- Singh, M.V. and Abrol, I.P. 1986. *Fert. News*, 37 (7): 17-27.

RAINFALL ANALYSIS AND CROP PLANNING IN UTTAR PRADESH

A.K. SRIVASTAVA, C.V.S. SASTRI AND R.N. GARG

Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Probabilities concept is adopted to demonstrate the importance of dry and wet spells for planning weather sensitive agricultural operations. Markov chain model was fitted to weekly rainfall data of four selected stations representing different agroclimatic zones of Uttar Pradesh (U.P.). Initial and conditional probabilities of occurrence of dry and wet spells of different lengths were estimated at these stations and their probabilities, during kharif season were computed.

Key words : Rainfall, crop planning, U.P.

In rainfed areas, kharif crops are most affected, not only due to insufficient seasonal rainfall but also its distribution during crop growing period, even during normal rainfall years. The success or failure of crop particularly under rainfed conditions is closely linked with the rainfall patterns/spells. Hence, a comprehensive idea regarding the probability of rainfall occurrence is essential in view of the economic implications of weather-sensitive agricultural operations like preparation of fields, sowing, transplanting, application of fertilizers (Virmani *et al.*, 1982, Das *et al.*, 1999).

Several workers used Markov chain probability model for dry/wet week rainfall analysis in India. In this paper Markov chain technique was applied to compute the probability of dry/wet spells at different probability levels of weekly rainfall, during the crop growing period of major kharif crops at four locations in Uttar Pradesh.

MATERIALS AND METHODS

General description of the study area :

Uttar Pradesh is one among the few states in the country, with a high percentage of net sown area viz, 70 per cent of the total reporting area as against 42 percent of all India figures. The productivity in the state has been higher than the national average with respect to pulses, sorghum, maize and bajra but lower in case of rice, sugarcane, cotton and oilseeds (ICAR, 1991).

Normally onset of south-west (SW) monsoon occurs around 13th June over the eastern end of the state and gradually covers the state by 25th June. About 80% of the total rainfall occurs during the four months of SW monsoon from June to September. The agroclimatic zones of Uttar Pradesh and their soil, major crops grown, annual average rainfall (IMD, 1994) are given below :

Data used

Daily rainfall data have been collected from National Data Center of India Meteorological Department, Pune of five stations (Saharnpur, Faizabad, Varanasi, and Gorakhpur) of Uttar Pradesh state. The daily data ranging from 25-30 years (1970 to 1999) are converted into weekly totals. The daily data from 1 June to 31 October (SMW 23-45) are classified as wet or dry weeks according to the rainfall amount exceeding or equal to the different threshold limits of 30, 40, 50 and 60 mm/week.

Methodology

The initial and condition probabilities have been computed based on Robertson (1982) for application of Markov Chain theory and given below :

$$P(W) = F(W)/n$$

$$P(D) = F(D)/n$$

Where

F = frequency

Rainfall of Zone	Representing district taken in the study	Annual average rainfall	Soil type	Major kharif crops grown
Low rainfall zone	Saharnpur	Less than 70 cm	Mainly recent alluvial	Barja, Maize, Jowar, Fodder crops
Moderate rainfall zone	Faizabad	85-100 cm	Alluvial	Paddy, Pearlmillet, Jowar, Pulses
Assured rainfall zone	Varanasi	100-110 cm	Alluvial	Paddy, Pulses
High rainfall zone	Gorakhpur	110-150 mm	Recent alluvial	Paddy, Pulses, Maize

P = Probability

n = Number of years of rainfall data

P (D) - probability of occurrence of a dry week in n years

P (W) - probability of occurrence of wet week in n years

F (D) - number of dry weeks in n years

F (W) - number of wet weeks in n years

Similarly the conditional probabilities are calculated by formulae

$$P(W/W) = \frac{F(W/W)}{F(W)}$$

$$P(D/D) = \frac{F(D/D)}{F(D)}$$

$$P(3D) = P(D)w_1 \cdot P(D/D)w_2 \cdot P(D/D)w_3$$

$$P(2D) = P(D)w_1 \cdot P(D/D)w_2$$

$$P(3D) = P(W)w_1 \cdot P(W/W)w_2 \cdot P(W/W)w_3$$

$$P(2W) = P(W)w_1 \cdot P(W/W)w_2$$

Where

F(D/D) = Number of dry weeks preceded by dry week

F(W/W) - Number of wet weeks preceded by wet week

P(D/D) - Conditional probability of dry week preceded by a dry week

P(W/W) - Conditional probability of wet week preceded by a wet week

P(2D), P(3D) - Probability of 2 and 3 consecutive dry weeks, respectively, starting with the week

P(2W), P(3W) - Probability of 2 and 3 consecutive wet weeks, respectively, starting with the week w₁, w₂, w₃ - indicate 1st, 2nd and 3rd consecutive weeks, respectively.

Many workers used different threshold values of rainfall for a wet and dry week period for different crops. In this study different value of weekly rainfall (30-60 mm range) were used as threshold for different kharif crops in low to high rainfall agroclimatic zones of Uttar Pradesh. The weekly threshold limits (slightly modified) with 50% probability used for crop planting in different agroclimatic region are as follows :

Kharif crops	Weekly rainfall limit
Jowar/Bajra	30 mm
Maize	40 mm
Rice	60 mm

RESULTS AND DISCUSSION

Temporal variation of wet/dry week probabilities during kharif season

The patterns of dry weeks and wet weeks show a considerable variation from year to year. The bimodal rainfall distribution was found at every station. During kharif crop growing period simple and conditional probabilities of getting wet and dry weeks at selected stations in U.P. with amounts of 30, 40, 50 and 60 mm as rainfall limits are shown in Tables 1-4. The conditional probability of wet week with 50% probability has a greater length (27-37 SMW) at Gorakhpur

as compared to other locations. The consecutive 2 and 3 wet weeks with 50% probability were one or two in number in almost every station. The dry week with 50% probability is very dominant during 38 to 45 SMW at every station. The largest spells of wet weeks were occurred either in July (27-31 SMW) and during August (34-37 SMW), because during this period the monsoon activity is its peak in these regions. This is also clear from the tables that the probability of occurrence of wet week was higher at Gorakhpur and Varanasi than the rest of the locations under study.

Monsoon withdraws from U.P. around first week of October and consequently it is noticed that probability of occurrence of dry spell followed by dry spell become considerably high after 39th standard meteorological week (SMW) at almost every station. So, it is necessary to consider these weekly probabilities for rainfall sensitive agricultural operations.

Spatial variation of wet/dry weeks probabilities during kharif season

It is also important for irrigation planning to know the probability of occurrence of consecutive dry period of two or three weeks in kharif season. If such a period of longer duration coincides with a sensitive phenological stage, it can affect the crop growth and development. It was also observed from Tables 1 to 4, that during kharif crop growing season, the probability of occurrence of wet week was higher (more than 70 probability) during 39-45 SMW and lower during beginning of the kharif season. The conditional probability of wet week preceded by a wet week and probability of occurrence of two or three consecutive wet weeks were considerably high in almost all locations, which starts during 27-30 and decrease thereafter from 34-37 SMW which coincides the vegetative and reproductive phase of most of the crops.

It was observed that the probability of a wet week preceded by a wet week were in the sequential order from Gorakhpur and followed by Varanasi followed by Faizabad and Saharanpur. In respect of probability of a dry week preceded by a dry week, was comparatively less in Varanasi and relatively more in

Gorakhpur and Saharanpur. Based on the length of dry periods at different locations, different crops have been recommended for each agroclimatic zone.

Crop planting according to weekly rainfall probability Jowar, bajra

These crops require less water for their growth and development and also suitable in rainfed cultivation. They recover after 1 to 2 weeks of consecutive dry spells. In the present study, only the dry spell of more than 2 weeks duration were considered detrimental, for its growth and development, because in monsoon season the rainfall and its distribution are sufficient for their growth of these crops, but the consecutive three dry weeks (30 mm) with 50% probability is detrimental and their number were 3 at Gorakhpur, 7 at Varanasi and Faizabad, and 9 at Sharanpur. This indicates that the crop like Jowar and Bajra, can be grown for grain purpose at Gorakhpur and for fodder purpose at rest four stations under rainfed condition.

Maize

The rainfall limit was fixed 40 mm/week for Maize crop and one week dry spell was not affecting the crop. Consecutive high rainfall (60 mm) has a negative impact if proper drainage were not made in the crop field. The number of 2 and 3 consecutive dry and wet weeks with 50% probability showed a large variation from east to west direction across the state. Though the crop pigeonpea have a much longer duration but required less amount of rain in its initial and vegetative phase. From the Tables (1-4) it can be observed that at stations like Gorakhpur, Varanasi Maize can be grown under rainfed condition but it required, slight rainfall (40 mm/week) during milking stage (37-39 SMW). But getting a weekly rainfall of 40 mm with 50% during milking stage, is negligible at these stations. Hence a light irrigation should be provided looking the failure of rainfall in crop growing period.

Paddy/Rice

Rice is water-loving plant and requires more water than any other crop in kharif season. The crop growth and yield are affected by one week dry spell and hence in this study both the

Table 2. Conditional wet, dry weeks and consecutive two and three wet and dry week probability (%) at Varanasi

SMW	P(W/W)			P(2W)			P(3W)			P(D/D)			P(2D)			P(3D)								
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm							
23	0	0	0	0	0	0	0	0	0	77	78	78	94	67	72	94	42	42	51	68				
24	0	0	0	5	5	0	3	3	0	86	86	93	100	55	55	67	72	35	35	39	44			
25	50	50	99	0	28	17	11	18	4	3	62	62	70	72	39	39	44	30	30	27	36			
26	71	71	50	40	33	28	11	25	20	9	64	64	58	61	39	39	50	19	21	21	28			
27	67	56	25	28	33	28	22	17	19	13	78	78	70	82	28	33	39	44	08	12	14	14		
28	75	71	80	75	50	39	33	22	23	21	50	54	54	57	11	17	17	0	0	09	10			
29	81	70	60	44	50	39	39	28	15	19	7	28	37	33	0	0	22	28	0	0	11	17		
30	64	58	63	50	39	28	28	11	32	15	5	0	57	62	05	22	33	02	02	10	14	14		
31	54	38	50	25	50	33	28	17	23	15	8	5	20	60	17	22	28	10	13	14	21			
32	82	67	55	50	33	28	17	17	25	17	8	10	43	44	42	17	22	28	03	07	11	20		
33	46	45	30	30	33	28	17	17	17	14	7	6	60	57	62	75	11	17	28	03	05	14	22	
34	75	62	50	60	38	33	22	17	31	20	11	8	20	30	42	61	06	11	22	28	01	04	13	16
35	50	50	40	37	44	33	22	22	28	12	5	5	25	33	50	50	11	17	33	03	07	13	13	
36	80	60	50	50	50	33	11	11	8	5	3	3	25	37	60	60	05	17	22	22	03	13	18	18
37	64	36	25	25	11	22	11	11	2	0	0	0	25	43	40	40	17	44	44	11	31	32	35	
38	17	25	25	25	5	11	0	0	1	0	0	0	50	80	80	80	50	55	55	61	46	48	51	57
39	20	0	0	0	5	0	0	0	0	0	0	0	69	71	71	78	67	72	78	62	67	72	78	
40	20	0	0	0	0	0	0	0	0	0	0	0	92	86	93	93	83	89	94	78	84	94	94	
41	0	0	0	0	0	0	0	0	0	0	0	0	94	100	100	100	89	94	94	100	89	94	100	100
42	0	0	0	0	0	0	0	0	0	0	0	0	94	94	100	100	94	94	100	100	89	94	94	94
43	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	94	94	100	94	89	94	94	94
44	0	0	0	0	0	0	0	0	0	0	0	0	94	94	94	94	89	89	94	94	89	94	94	94
45	0	0	0	0	0	0	0	0	0	0	0	0	94	94	100	100	94	94	100	100	94	94	100	100

[illegible]

conditional probability and consecutive one week dry/wet spell period were considered. For nursery sowing, 60 mm with 50% probability is required and the conditional probability indicate that sowing of rice at Faizabad and earlier around the 23rd to 24th and was late at Shaharnpur 28-29th SMW under rainfed condition. The peak vegetative stage and reproductive stage will be normally completed around 38th to 39th SMW. From the analysis for 2 consecutive wet weeks period, it is found that at all stations are favorable for cultivation of short duration rice variety under rainfed condition but

required a protective irrigation during grain filling stage (Tables 1-4). The results lead to the conclusion that under rainfed condition at these stations, cultivation of a long duration rice variety should be not advisable. At those stations, where irrigation water is available, rice crop cultivation and their irrigation management should be made, taking the information of rainfall probability analysis. However there are differences in irrigation management and crop planning and this should be done station wise according to the rainfall situation during crop period.

REFERENCES

- Das, H.P., Anhyankar, R.S., Bhagwat, R.S. and Nair, A.S. 1999. Probability estimates of dry spells and wet spells for use in agromet advisory service, Meteorology beyond 2000, Proceeding of National Symposium. TROPMET-99, RMC, Chennai. 1999, 417-421.
- ICAR. 1991. Agroclimatic Zone Specific Research. Editor: Ghosh, S.P., 403-421.
- IMD. 1994. Optimum crop sowing dates for Uttar Pradesh during monsoon. Meteorological Monograph, AGRIMET/NO., 15/1993.: 8.
- Robertson, G.W., 1982. Frequency and probability of dry and wet spells. WMO Tech. Note No. 179 : 149-153.
- Virmani, S.M., Sivakumar, M.V.K. and Reddy, S.J. 1982. Rainfall probability estimates for selected locations of semi arid India. ICRISAT Research Bulletin No. 1.

RESPONSE OF APPLYING ACETOBACTER BIO-CULTURE TO AUTUMN SUGARCANE UNDER INTERCROPPING WITH RHIZOBIUM INOCULATED PEA AND FRENCHBEAN

S.C. SINGH, S.N. SINGH*, V.C. JADON AND S.B. SINGH

U.P. Council of Sugarcane Research
Shahjahanpur-242 001, U.P.

ABSTRACT

Experimental results showed that the germination of cane buds and number of shoots were not affected significantly due to application of bio-cultures and intercropping of pea and frenchbean in sugarcane. Application of *Acetobacter diazotrophicus* culture @ 4 kg/ha in sole cane did not show any significant difference in number of millable canes and cane yield over no bio-culture application but, when it was applied in different treatments of pea and frenchbean (uninoculated or inoculated with *Rhizobium* culture) intercropped sugarcane, produced significantly higher number of millable canes and cane yield as compared to no bio-culture application. Intercropping of *Rhizobium* inoculated pea and frenchbean with sugarcane gave higher cane yield over uninoculated counterparts but not at the level of sugarcane.

Key words : Acetobacter, intercropping, sugarcane, pea, frenchbean.

Nitrogen has been considered as one of the most important nutrients for the growth and development of sugarcane (*Saccharum* species complex) under various agro-climatic conditions. A vast majority of Indian farmers can not afford adequate application of nitrogen due to escalating prices of chemical nitrogen fertilizers in recent years. Intercropping of short duration N-fixing legumes in inter-row spaces of sugarcane in autumn season could be one of the preferable choice for N-economy and increasing the total production (Godara, 1995). Legumes are able to utilize the unlimited air nitrogen and make it available to crop plants in association with *Rhizobium* bacteria. In addition to above, legumes are also known to improve soil structure and when ploughed into soil, the nitrogen content of the soil is augmented. The agricultural practices which are known for several years such as rotation of crops and green manuring are based on the soil enriching power of legumes (Subba Rao *et al.*, 1993). Another important biological N-fixing agent i.e. *Acetobacter diazotrophicus* referred as black area, has been reported to substantially reduce *diazotrophicus* referred as black area, has been reported to

substantially reduce inorganic N application to the extent of 50% in sugarcane (Sundara, 1998). With a view of provide unique opportunity in the agricultural system and to sustain soil fertility and crop production, this experiment was carried out to assess the response of applying *Acetobacter* bio-culture to autumn sugarcane under intercropping with *Rhizobium* inoculated pea (*Pisum sativum* L.) and frenchbean (*Phaseolus vulgaris*).

MATERIALS AND METHODS

The response of applying *Acetobacter* bio-culture to autumn sugarcane in intercropping with *Rhizobium* inoculated pea and frenchbean with respect to N-economy and cane yield was studied in an experiment conducted at the research farm of U.P. Council of Sugarcane Research, Shahjahanpur during 1998-2000, 1999-2001 and 2000-2002 taking two rows of above intercrops in between 90 cm spaced cane rows. The soil of experimental field was sandy loam in texture, slightly alkaline in reaction (pH 7.8), low in available organic carbon, nitrogen, medium in phosphorus and potash. Different combinations of treatment as given in Table 1 were tried in randomized block design with three replications keeping test varieties of

*Senior Scientist, Indian Institute of Sugarcane Research, Lucknow-226002.

Table 1. Growth and yield of autumn cane and its quality (CCS%) and pod yield of intercrops as influenced by applying *Acetobacter* bio-culture in intercropping with *Rhizobium* inoculated pea in frenchbean (Pooled data of three years)

Treatments	Germination (%)	Shoots (000/ha)	Millable canes (000/ha)	Cane yield (t/ha)	Available sugar content (CCS%)	Pod yield of intercrops (q/ha)
T ₁ : Sole cane + No <i>Acetobacter</i>	43.17	250	135	104.92	10.62	-
T ₂ : Sole cane + No <i>Acetobacter</i> @ 4 kg/ha	43.10	260	139	109.08	10.75	-
T ₃ : Cane + pea (un ino) + no <i>Acetobacter</i>	42.88	248	138	106.16	10.82	52.83
T ₄ : Cane + pea (un ino) + <i>Acetobacter</i> @ 4 kg/ha	42.82	284	143	111.24	11.03	53.24
T ₅ : Cane + pea (ino. with <i>Rhizobium</i>) + No <i>Acetobacter</i>	42.76	251	140	108.54	10.81	59.94
T ₆ : Cane + pea (ino. with <i>Rhizobium</i>) + <i>Acetobacter</i> @ 4 kg/ha	42.54	260	145	112.92	11.01	60.31
T ₇ : Cane + frenchbean (un ino.) + No <i>Acetobacter</i>	41.78	255	139	107.05	10.93	48.23
T ₈ : Cane + frenchbean (un ino.) + <i>Acetobacter</i> @ 4 kg/ha	44.52	260	145	112.80	10.95	48.76
T ₉ : Cane + frenchbean (ino. with <i>Rhizobium</i>) + No <i>Acetobacter</i>	42.60	255	140	108.85	10.96	55.46
T ₁₀ : Cane + frenchbean (ino. with <i>Rhizobium</i>) + <i>Acetobacter</i> @ 4 kg/ha	43.89	266	147	114.56	10.80	56.65
C.D. (P=0.05)	NS	NS	6.89	5.86	NS	-

Ino. = Inoculated, Unino. = un inoculated.

sugarcane, pea and frenchbean as CoSe 92423, Arkel and Pant Anupama, respectively. Sugarcane was planted in the mid of October and sowing of pea and frenchbean as intercrops were done within 2-3 days after planting of sugarcane in all the three cropping seasons. Before sowing, seeds of pea and frenchbean were inoculated with effective strain of *Rhizobium* (200 g of *Rhizobium* culture for 8 kg of seed) obtained from G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar) while, *Acetobacter* bio-culture was arranged from SPIC Foundation, Chennai and applied 2 times @ 4 kg/ha; one at 45 days after sugarcane planting and another one at peak tillering phase as side dressing. Half of the recommended dose (180 kg/ha) of N and 60 and 40 kg/ha of P and K, respectively to sugarcane crop while, 40 and 30 kg/ha of P and K were given to pea and frenchbean separately at the time of planting/sowing. Remaining N dose to sugarcane was top-dressed after pod picking of intercrops incorporating legumes residues in between cane rows and thereafter intercultured the field at proper soil moisture. Observations on growth characters and yield of intercrops and cane were recorded at their respective growth/harvesting stages and computed for statistical significance. Juice samples were drawn at the time of sugarcane harvesting and analyzed for available sugar content (CCS%) in cane (Spencer and Meade, 1955).

RESULTS AND DISCUSSION

Experimental results presented in Table 1 indicated that the germination of cane buds and number of shoots did not show any significant difference due to application of bio cultures and intercropping of pea and frenchbean in sugarcane and were more or less similar. Further, it revealed that the application of *Acetobacter diazotrophicum* cultures in sole cane did not show any significant difference in number of millable canes and cane yield over no bio-culture application but, when it was applied in different treatments of pea and frenchbean (uninoculated or inoculated with *Rhizobium* culture) intercropped sugarcane, produce significantly higher number of millable canes and cane yield as compared to no bioculture application. It thus,

reflected its significant response in organic matter improved soil condition caused due to incorporation of pea and frenchbean residues left over in between cane rows after pod picking in standing crop of sugarcane which might have increased the organic especially *Acetobacter* intensity in soil and utilization efficiency of applied nitrogen in the soil. As a result of faster decomposition of these residues due to narrower C : N ratio as compared to that of cereal crops which enhanced growth and yield of cane. Rekhi and Meelu (1983) reported that incorporation of green gram straw into the soil and application of 60 kg N/ha produced the rice grain yield comparable to 120 kg N/ha through urea alone.

Prasad and Palaniappan (1987) and Prasad and Power (1991) also reported the similar findings. Intercropping of *Rhizobium* inoculated pea and frenchbean with sugarcane gave numerically higher cane yield over uninoculated counterparts though the differences were not significant statistically. However, the effect of applying *Rhizobium* bio-culture either to pea or frenchbean produced higher pod yields as compared to no bio-culture application. Rewari and Tilak (1988) are in close conformity with the above findings. Different treatments under this study did not show any significant difference in available sugar percent (CCS%) in cane and were more or less identical.

REFERENCES

- Godara, B.R. 1995. Economic feasibility of green gram intercropping in spring planted sugarcane in north-west Rajasthan. *Proc. STA 57th Conv.* : 149-152.
- Prasad, R. and Palaniappan, S.P. 1987. Pulse crop residues as N source in rice based cropping system. *Intl. Rice Research News Letter*, 12(1) : 31.
- Prasad, R. and Power, J.F. 1991. Crop residue management. *Adv. Soil Sci.*, 15 : 205-251.
- Rekhi, R.S. and Meelu, O.P. 1983. Effect of complementary use of moong straw and inorganic fertilizer N on the N availability and yield of rice. *Oryza*, 20 : 125-129.
- Rewari, R.B. and Tilak, K.V.B.R. 1988. Microbiology of pulses. In *Pulse Crop* (Eds. B. Baldev, S. Ramanujam and H.K. Jain). Oxford & IBH Publ. Co. (Pvt.) Ltd., New Delhi, India : 373-411.
- Spencer, G.L. and Meade, G.P. 1955. *Cane Sugar Handbook*. A manual for cane sugar manufactures and their chemistry. John Wiley & Sons Inc., New York.
- Subha Rao, N.S. Venkatraman, G.S. and Kannaiyam, S. 1993. *Rhizobium* and legume root nodulation, In *Biological Nitrogen Fixation*. Indian Council of Agricultural Research, New Delhi : 3.
- Sundara, B. 1998. Biofertilizers applications in sugarcane. In *sugarcane Cultivation*. Vikas Publishing House Pvt. Ltd., New Delhi : 144.

EVALUATION OF PUNJAB AMERICAN COTTON (*G. HIRSUTUM* L.) GENOTYPES FOR TOLERANT TO HIGH TEMPERATURE AND THEIR PERFORMANCE DURING SPRING SUMMER SEASON

R.P. SINGH, JAGMAIL SINGH, C.B. LAL, SUNITA AND K. ELAYARAJA

*Division of Genetics
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Pooled analysis of data showed significant genotypic differences for seed cotton yield and yield components like number of bolls/plant opened till June 30, boll weight, seed index, ginning out turn, lint index etc. The data on mean performance over the two-years clearly showed superior performance of P 17-52-10 in comparison to check RS 875 and other genotypes studied. P17-52-10 showed highest seed cotton yield (662.3 kg/ha), number of total bolls/plants (14.2), number of bolls/plant opened up to June 30 (10.9), boll weight (2.8 g) seed index (8.1 g) and lint index (4.1 g). Seed of summer picked crop of P-17-52-10 also showed 70% germination against 68% of RS 875 and thus met the minimum 65% germination requirement set by seed certification agencies. P 17-52-10 also showed good fibre quality parameters like fibre length (25.5 mm), uniformity ratio (50.6), micronaire (4.0), fibre strength (18.8 g/tex) and fibre elongation (5.7%).

Key words : Tolerance, high diurnal temperature, fibre quality index (FQI), plant type.

There has been change in the rainfall pattern as well as increase in temperature. According to the report of Inter-Government panel on climate change (IPCC 1990), global temperatures are expected of rise by 4°C. There is, therefore, an urgent need to identify/develop genotypes which are resistant/tolerant to high diurnal temperatures and low relative humidity. There is also scope for growing crop in the northern states after harvesting of potato or as in intercrop in mungbean/urdbean or sugarcane etc. Such a crop will require being sown in the last week of February and harvesting to be completed by June end. The reproductive phase of the crop will be thus exposed to unusually high diurnal temperatures and low relative humidity. The varieties for such a situation should be tolerant to high temperatures and should be able to flower and set bolls and give economical yield with acceptable fibre quality.

Systematic research programme, has therefore, taken up at the Indian Agricultural Research Institute, New Delhi under a project

funded by NATP. The major objective of this research is to identify genotypes, which can tolerate high diurnal temperatures, flower and set bolls under these conditions, mature early in about 120-130 days and also have acceptable fibre quality.

MATERIALS AND METHODS

Seven genotypes viz. PIL 8, LH 1948, LH 1960, LH 1972, LH 1995, F 1906 and P 17-52-10 were evaluated for important morphological, economic and fibre quality traits against the check RS 875 during spring/summer 2002 and 2003. The crop was planted on 22nd February and 25th February during 2002 and 2003, respectively. Each genotype was grown in 4 row (4.2 m long) plots in RBD fashion with 3 replications. The plant to plant and row to row spacing were kept at 30 cm and 67.5 cm respectively. Three irrigation during 2002 and two during 2003 were applied. No spraying of pesticides was done during both years, as there was no incidence of pests and/or diseases during the season. Data were recorded on important characters and pooled analysis was done.

RESULTS AND DISCUSSION

Non-significant differences due to the years were observed for number of sympodia/plant and total number of bolls/plant. These two are important yield components and results suggest consistent performance of the genotypes for these characters. Pooled analysis further showed significant genotypic differences for seed cotton yield, number of total bolls/plant, number of bolls/plant opened till June 30, boll weight ginning outturn (GOT), seed index, lint index and plant height. Genotypic differences for number of days of germination, number of days to initiation of squaring, 50 flowering and first boll opening, internodal length and number of sympodia/plant were non-significant. These results suggest that genetic variability amongst the genotypes evaluated, does exist for economically important characters and genotypes with high yield potential during spring/summer season could be developed.

Data on the mean performance of genotypes over two year period for important characters including fibre quality are given in Table 1. A reference to Table 1 shows that F 1906 took maximum mean number of days to germination (10.2), while lowest mean was recorded in check RS 875 (8.4). As against this, P 17-52-10 recorded 9.5 mean number of days for germination. The mean number of days to first square formation varied from 44.9 in LH 1960 to 46.5 in PIL 8. P 17-52-10 took an average of 45.7 days to first square formation as against 45.9 by RS 875. The Pusa genotype P 17-52-10 took minimum mean number of days (64.3) to the appearance of first flower as against the 66.3 by the check RS 875. Similar trend was also found with regard to mean number of days to first boll opening, which were 98.5 and 99.7 for P17-52-10 and RS 875, respectively. It also showed lowest 1st fruiting node being 4.2 against 4.6 in RS 875.

The highest mean number of monopodia per plant was observed to be 0.4 in case of LH 1948 and LH 1972 and the minimum was 0.2 in F 1906. The mean number of monopodia/plant was 0.3 in P 17-52-10 as compared to 0.3 in the check RS 875. P 17-52-10 recorded lowest mean (20.7) for number of sympodia/plant as compared to 28.3

being the highest in PIL 8 and 22.5 in check RS 875. It also recorded lowest plant height (63 cm) as compared to highest of 94.1 cm in LH 1960 and 82.0 cm in RS 875. The data presented above, especially in respect of first fruiting node, internodal length, plant height, number of days to first flowering and first boll opening suggest that the genotype P 17-52-10 was relatively compact and earlier in maturity in comparison to check RS 875 and other genotypes studied.

The genotype P 17-52-10 showed highest mean boll weight of 2.8 gm as compared to the lowest 1.9 gm recorded in check RS 875. The trend was similar in respect of seed index, highest being 8.1 gm in P 17-52-10 and PIL 8 and lowest being 6.8 gm in RS 875 and LH 1995. Seed index and boll weight are important yield component and coupled with number of bolls/plant are major contributors to seed cotton yield. The mean number of opened bolls/plant up to 30th June and mean total number of bolls/plant were found to be highest in P 17-52-10 being 10.9 and 14.2, respectively. In comparison to this the respective values were 6.5 and 10.9 in case of check RS 875. As a result, the highest mean seed cotton yield (662.3 kg/ha) was recorded in P 17-52-10 against 217.4 kg/ha in case of check RS 875. The mean lint index of 4.1 and ginning outturn of 33.6% in case of P 17-52-10 further support its overall superior performance under conditions of high diurnal temperatures and low relative humidity.

The fibre quality parameters viz; fibre length, uniformity ratio, fineness, fibre strength, elongation and FQI were also studied during the two years. P 17-52-10 showed acceptable fibre quality with mean fibre length of 25.5 mm, uniformity of 50.6, micronaire of 4.0 and fibre strength of 18.8 g/tex. The fibre strength at 18.8 g/tex is quite good when compared to that of the varieties recommended for kharif cultivation in the northern zone.

The weather during spring/summer is characterized by low temperatures at the time of crop sowing, establishment and initial growth and very high diurnal temperatures with low relative humidity during reproductive phase from April to June (Table 2).

It may be appropriate to emphasize that the

Table 1. Mean performance of cotton strains grown during spring summer seasons 2002 and 2003

Culture	Days to germination	Days to square initiation	Days of Ist flower opening	Days to Ist boll brusting	Plant height (cm)	Monopodia /plant	Sympodia /plant	Ist Fruiting Node	Internodal distance (cm)
PIL 8	9.5	46.5	66.85	103.2	92.4	0.4	28.3	4.3	3.0
LH 1948	9.7	46.3	67.0	101.2	92.0	0.4	25.5	4.3	3.1
LH 1960	9.5	44.9	64.7	101.7	94.1	0.3	25.4	4.7	3.3
LH 1972	9.9	45.8	66.4	100.4	83.2	0.4	24.8	4.0	3.1
LH 1995	9.7	45.0	65.9	101.4	72.9	0.4	23.2	4.6	2.7
F 1906	10.2	46.5	66.5	102.0	86.6	0.2	22.8	4.6	3.0
P 17-52-10	9.5	45.7	64.3	98.5	63.0	0.3	20.7	4.2	2.6
RS 875 (Check)	8.4	45.9	66.3	99.7	82.0	0.3	22.5	4.6	3.0
Culture	Boll No. (Opened)/ plant upto 30th June	Boll No. (Total)/ plant upto 30th June	Boll wt. (gm)	Ginning outturn %	Seed index (gm)	Lint index (gm)	Yield kg/ha		
PIL 8	4.6	7.5	2.1	31.3	8.1	3.7	239.5		
LH 1948	4.9	8.8	2.3	34.3	7.2	3.7	141.3		
LH 1960	5.4	8.9	2.3	34.9	7.7	4.1	236.4		
LH 1972	3.1	6.3	2.3	32.8	7.6	3.7	226.5		
LH 1995	8.7	12.2	2.2	35.4	6.8	3.7	298.7		
F 1906	6.3	9.6	2.0	33.5	7.1	3.6	238.8		
P 17-52-10	10.9	14.2	2.8	33.6	8.1	4.1	662.3		
RS 875 (Check)	6.5	10.9	1.9	32.9	6.8	3.3	217.4		
Culture	Fibre length(mm) (2.5/S.L.)	Fibre uniformity ratio	Fibre fineness (Micronaire value)	Fibre Strength (g'/tex at 3.2 mm gauge)	Elongation (%)	FQI			
PIL 8	25.4	49.7	4.0	22.3	4.6	272			
LH 1948	25.45	50.15	3.58	19.2	5.8	258.45			
LH 1960	26.95	50.6	3.5	20.5	5.3	287			
LH 1972	24.6	50.3	3.1	21.8	5.5	311			
LH 1995	25.65	48.95	4.2	20.8	6.05	260.25			
F 1906	25.5	49.4	3.6	20.9	5.2	286			
P 17-52-10	25.5	50.6	4	18.8	5.7	240.09			
RS 875 (Check)	25.8	49.9	4	21	5.8	273			

Table 2. Weather data for years 2002-2003 (Feb. to June) taken during Spring summer cotton crop at IARI, New Delhi

Maximum mean temperature							Minimum mean temperature						
2002							2003						
	Mean	Range		Mean	Range		Mean	Range		Mean	Range		
Feb.	19.9	13.0-24.0	(15.07)	20.2	13.5-23.6	(14.4)	6.4	2.9-1.0	(41.84)	7.39	4.0-12.5	(36.81)	
	25.6	22.2-29.6	(10.19)	23.3	20.1-27.5	(10.31)	10.5	7.8-17.0	(27.17)	11.93	7.4-15.5	(21.55)	
Mar	26.8	22.4-29.2	(7.36)	25.0	17.2-29.2	(11.83)	12.3	7.5-18.5	(24.37)	11.63	7.5-17.2	(25.86)	
	33.5	29.3-36.5	(4.95)	31.1	28.3-33.0	(4.69)	15.6	11.0-21.0	(18.62)	15.78	13.5-20.5	(12.82)	
April	35.9	27.5-39.8	(8.63)	36.3	31.5-40.5	(8.55)	19.3	16.0-24.0	(12.53)	19.88	16.0-27.5	(15.84)	
	40.0	36.5-43.2	(4.79)	38.2	35.0-41.4	(5.59)	22.8	19.5-27.5	(12.0)	20.47	17.8-22.8	(7.61)	
May	41.7	36.9-45.0	(5.97)	38.1	34.4-41.0	(4.46)	26.5	19.5-33.0	(14.75)	22.12	17.0-29.5	(20.09)	
	39.6	29.0-46.0	(13.5)	40.7	33.5-44.5	(6.54)	24.9	19.5-31.3	(13.98)	25.6	21.0-32.5	(12.16)	
June	38.8	31.0-43.0	(8.9)	43.4	38.6-46.3	(4.31)	28.0	23.0-31.0	(8.18)	29.81	26.2-36.0	(7.43)	
	41.7	33.8-43.0	(6.93)	37.1	32.6-42.5	(8.21)	30.6	27.0-30.4	(2.94)	27.59	23.5-30.5	(6.16)	
Sun-shine hrs													
Relative humidity (%)													
2002							2003						
	Mean	Range		Mean	Range		Mean	Range		Mean	Range		
Feb.	68.1	50.0-95.0	(18.72)	73.6	63.0-93.0	(10.55)	5.4	0.0-8.5	(51.67)	5.83	0.0-8.8	(57.84)	
	59.5	43.0-73.0	(11.95)	75.9	67.0-87.0	(7.89)	5.1	2.3-9.8	(42.12)	6.59	0.3-9.6	(43.01)	
Mar	52.5	33.0-92.0	(25.02)	58.0	36.0-75.0	(18.86)	7.5	0.0-10.3	(35.76)	6.97	1.0-10	(36.01)	
	52.0	14.0-62.0	(21.22)	59.6	50.0-66.0	(8.73)	10.7	6.8-10.8	(9.84)	6.96	1.9-9.7	(32.46)	
April	40.5	30.0-50.0	(16.39)	42.9	33.0-55.0	(15.13)	7.9	1.5-10.4	(28.86)	8.25	3.8-9.8	(19.12)	
	36.7	24.0-51.0	(22.72)	40.3	30.0-48.0	(13.11)	7.6	3.0-10.0	(26.7)	8.1	3.6-10.5	(23.98)	
May	40.5	22.0-51.0	(26.16)	38.3	25.0-53.0	(22.12)	7.0	2.4-10.1	(28.39)	6.47	0.0-9.8	(44.92)	
	46.2	23.0-76.0	(38.92)	41.3	30.0-71.0	(28.64)	5.1	0.0-10.3	(70.96)	5.77	0.0-9.6	(53.40)	
June	50.9	39.0-72.0	(15.7)	41.0	31.0-57.0	(17.76)	7.3	0.0-9.2	(32.66)	4.83	0.0-9.8	(82.01)	
	62.1	47.0-76.0	(15.92)	65.7	46.0-84.0	(16.7)	7.5	1.2-9.1	(29.65)	4.21	0.0-9.5	(75.75)	

15 days mean maximum temperature ranged from 35.9°C to 43.4°C and minimum shot up to 30.6°C during the flowering and boll development stages of the crop. The relative humidity ranged from 36.7% to 65.7% during same period. The study is very significant in identifying genotypes, which can give good seed cotton yield with acceptable fibre quality and high seed index. The seeds harvested from summer crop showed up to 70% germination under laboratory conditions against 68% in the check RS 875. The meets the minimum acceptable seed germination requirement of 65% fixed by the seed certification agencies. Powell (1969) in a controlled environment study of cotton fruiting had reported that plants grown at constant temperature of 29.4°C did not produce viable pollen in any of the 5 varieties tested and did not set fruit when grown at 32.2°C and pollinated with viable pollen. Similar finding were reported by Hoffman and Rawlins (1970) when they found negligible boll set at maximum temperature of 38°C and minimum of 28°C because anthers failed to dehisce. Mayer (1969) also found that daily maximum temperatures above 38°C, 15 to 16 days before anthesis affected sterility more than any factors of external environment. Reddy *et al.* (1997) in a study at Mississippi Starkville (USA) also observed that temperatures above 28°C were detrimental to mid and late season boll retention and growth. No fruits were retained to maturity at 28°C to 30°C. Reddy *et al.* (1992 b) also reported that number of bolls produced, bolls retained and percent retention were progressively reduced as time per day at 40°C was increased. Three week exposure to 40°C for 2 hrs and 12 hours per day resulted in 64% and 0% bolls retained, respectively.

Singh *et al.* (2003) reported about the desirable leaf properties of genotype P 17-52-10. The leaves at this particular genotype demonstrated their sun tracking ability in order to avoid excess heat during mid noon under very hot summer and they become droopy in order to expose lesser area to direct sunlight. This

character is prominent in upland cotton and was described as leaf heliotropism by Ehleringer and Hammond (1987).

The present study shows the existence of genetics variability among is variable different genotypes under high diurnal temperature and low relative humidity conditions prevalent during April to June in North India, suggesting thereby scope of identify suitable genotypes, which can set bolls and give high seed cotton yield without adverse effect on fibre quality. As stated above the 15 days mean maximum temperature ranged between 35.9°C to 43.4°C and the highest minimum mean was 30.6°C coupled with low relative humidity. It was under these conditions of unusually high temperatures and low humidity that the seven genotypes included in this study was evaluated. P 17-52-10 was found to the best among the 7 genotypes evaluated during summer season in the two years study and was obviously tolerant to high diurnal temperatures prevalent in this part of the country. The present study further confirms that the heat tolerant cotton genotypes could be developed as reported earlier by Singh and Singh (1993) and Singh *et al.* (2002). These genotypes could be grown during spring summer season as a crop that can be matured with in 125-130 days. The fibre quality from such genotypes is comparable to that of the normal season grown.

As the global temperatures are expected to rise due to green house effects and changing environment conditions, selection for increased tolerance to high temperatures is more essential. Such genotypes can also be grown successfully during spring/summer season in northern India as a sole crop after potato or as intercrop with summer mung or urdbean or sugarcane. Since the incidence of insect pests and diseases during summer is nil to negligible, the crop can be growing without the use of chemical pesticides in an environmental friendly manner and at reduced cost of cultivation.

REFERENCES

- Ehleringer, J.R. and Hammond, S.D. 1987. Solar tracking and photosynthesis in cotton leaves. *Agricultural and Forest Meteorology*, **39**, 25-35.
- Hoffman, G.J., and Rawlin, S.L. 1970. Infertility of cotton flowers at both high and low relative humidities. *Crop Science*, **10** : 721-723.
- IPCC. 1990. Intergovernmental Panel on climate change. (Working Group I), climate change, the IPCC Scientific Assessment. Edited by Houghton and J.J. Eppanarous, Cambridge University Press.
- Meyer, V.G. 1969. Some effects of genes, cytoplasm and environment on male sterility of cotton (*Gossypium*). *Crop Science*, **9** : 237-242.
- Powell, R.D., 1969. Effect of temperature on boll set and development of *G. hirsutum* cotton. *Growing Review*, **46** : 29-36.
- Reddy, K.R., Hodges, H.F., and Mckinion, J.M., 1992
b. Temperature effects on cotton fruit retention. *Agronomy Journal*, **84** : 26-30.
- Reddy, K.R., Hodges, H.F., and Mckinion, J.M., 1997. A comparison of scenarios for the effect of global climate change on cotton growth and yield. *Australian Journal of Plant Physiology*, **24** : 707-713.
- Singh, R.P., Singh, Jagmail, Lal, C.B., Sunita and Elayaraja, K. 2003. Development of suitable cotton *G. hirsutum* plant type. ICAR News. vol IX (4) : 14-16.
- Singh, M., and Singh, V.P., 1993. Development of upland cotton (*G. hirsutum* L) for spring summer cultivation. *Indian J. Agric. Sci.*, **63**(10) : 660-661.
- Singh, R.P., Singh, V.P., Singh, M., and Lal, C.B. 2002. Selection of tetraploid cotton (*Gossypium* spp) tolerant to high temperature and low relative humidity during spring summer season. *New Botanist*. (XXIX) : 27-34.

EFFECT OF TILLAGE PRACTICES AND IRRIGATION SCHEDULES ON PERFORMANCE OF CASTOR IN RICE FALLOWS

P. SESA SAILA SREE¹, B. BHASKAR REDDY² AND P. MARY KAMALA

*Department of Agronomy
College of Agriculture, Rajendranagar, Hyderabad*

ABSTRACT

The seed yield recorded by ploughing twice with country plough followed by working twice with power tiller rotovator; and tractor tilling with cultivator twice followed by rotovating twice with power tiller was comparable and significantly superior to that recorded with tractor tilling with cultivator twice followed by harrowing twice with tractor drawn offset disc harrow; and ploughing twice with country plough alone. Significantly higher plant stand, more number of capsules per plant, longer primary spikes and higher 100 seed weight in the former two treatments contributed to higher seed yield over that of latter two treatments. Among the IW/CPE ratios, irrigations scheduled at 0.4 IW/CPE resulted in significantly higher seed yield than that of 0.6 IW/CPE ratio and yield in the later treatment was significantly higher over that of 0.2 IW/CPE ratio.

Key words : Castor, tillage practices, IW/CPE ratios.

In areas where there is sufficient moisture for cultivation of second rice crop, irrigated-dry crop like castor could be grown successfully after kharif rice with limited water available in season. However, in a rice - ID crop sequence, the reduced turn around time between the harvest of rice crop and sowing of upland crop of castor often leads to inadequate land preparation and sub optimal stand establishment in fields preceded by rice under puddle conditions. Further cultivation of wet soil mostly produced cloddy surface in the field that results in poor seed-soil contact. The compact sub soil horizons created through puddling the rice soils though benefit the low land rice, seriously constrain the production of succeeding non-rice crops. This has necessitated the need for development of tillage practices for castor especially in view of contrasting tillage requirements as compared to rice. In spite of this, water requirement of castor in soils that follow flooded rice are entirely different from that grown after an upland crop. Hence, the present investigation was carried out to generate

information on suitable tillage practice and optimum irrigation schedule for late rabi/early summer castor grown after kharif rice.

MATERIALS AND METHODS

A Field experiments was conducted for two consecutive summer seasons of 1996-97 and 1997-98 at the Agriculture College Farm, College of Agriculture, Rajendranagar, Hyderabad. The soil of the experimental site was sandy clay loam in texture with available N 150.1 kg/ha, available P₂O₅ 22.8 kg/ha and available K₂O 200 kg/ha and pH 8.0. The treatments comprised four tillage practices viz., ploughing twice with country plough alone, ploughing twice with country plough followed by working twice with power tiller rotovator, tractor tilling with cultivator twice followed by rotovating twice with power tiller; and tractor tilling with cultivator twice followed by harrowing twice with tractor drawn offset disc harrow and three irrigation schedules viz., irrigation at IW/CPE ratios of 0.6, 0.4 and 0.2. The design followed was strip plot keeping tillage practices in main plot and irrigation levels in sub plots. The IW/CPE ratios of 0.6, 0.4 and 0.2 were maintained by using cumulative pan evaporimeter (CPE) values of 83.3, 125 and 250

¹Scientist (Agro), Regional Agricultural Research Station, Nandyal.

²Associate Director of Research, Regional Agricultural Research Station, Jagtial.

mm, respectively at 50 mm depth of irrigation water (IW). CPE was taken as a sum of daily evaporation from USWB Class 'A' open pan evaporimeter minus precipitation from the date of previous irrigation. Irrigations were scheduled as per treatments by measuring with water meter. Castor hybrid 'GCH 4' was sown @ 6 kg/ha on 10 January and 25 December during 1997 and 1997-98, respectively. A uniform dose of 40-60-30 NPK kg/ha was applied as basal and 20 N kg/ha was applied at 30-35 DAS and 20 kg N/ha was applied at 70-75 DAS. The observations were recorded on different growth parameters, yield attributing characters and seed yield in both the years and economics of treatments was worked out taking into consideration the additional cost of treatment and the gross value of produce. The data was statistically analyzed by using standard procedure.

RESULTS AND DISCUSSION

Effect of tillage practices

Ploughing twice with country plough followed by working twice with power tiller rotovator resulted significantly higher plant stand over the other tillage practices. On the other hand, ploughing twice with country plough alone resulted significantly lower plant population as compared to other treatments (Table 1). The tillage treatments involving rotovation resulted in significantly higher dry matter production, more number of capsules per plant, longer primary spikes, more-100-seed weight and shelling percentage (Table 1) as compared to those of tillage practices without rotovation. In both the years, seed yield in the treatments of tractor tilling with cultivator twice followed by rotovating twice with power tiller and ploughing twice with country plough followed by working twice with power tiller rotovator was on par with each other and superior to tractor tilling with cultivation twice followed by harrowing twice with tractor drawn offset disc harrow which in turn was superior to that of ploughing twice with country plough alone. Both the rotovation treatments resulted in significantly higher oil yield over that of treatments without rotovation (Table 2). A low bulk density consequently resulted in low

penetration resistance under these two rotovation treatments and this was beneficial in keeping the seedbed comparatively looser for a longer duration. The increased seed yield in the above two treatments was due to improvement in growth parameters and yield attributes. Low availability and reduced translocation of photosynthates to developing capsules due to inadequate tillage provided in the treatment of ploughing twice with country plough alone might have resulted in poor filling, lower 100-seed weight and ultimately lower seed yields (AICRP on SPCIP, 1987; Kumar, 1991 and Pratibha et al., 1994). The net monetary returns of Rs. 4752 per ha and higher B : C ratio of 1.34 was obtained when the land was prepared by ploughing twice with country plough followed by working twice with power tiller rotovator.

Effect of irrigation regimes

The results showed that irrigation at 0.4 IW/CPE ratio produced significantly higher seed and oil yields over 0.6 IW/CPE which in turn significantly higher as compared to that of 0.2 IW/CPE during both the years. The increase in yield was associated with increase in number of capsules per plant, length of primary spike and 100 seed weight. Improvement in yield attributes with increased supply of irrigation water was due to improvement in dry matter production which facilitated production of longer primary spikes (Table 1) which ultimately produced more number of capsules and hence higher seed yield per plant as compared to that obtained under both high and low irrigation regimes.

Irrigating the crop at IW/CPE ratio of 0.6 resulted in excess soil moisture due to which wilting symptoms were observed in some of the plants and eventually the yield components and yield were affected. The incidence of wilt was reported by Raghavaiah (1999) in the hybrids GCH 4 and DCH 30 and sensitivity of castor to excess moisture and waterlogging was reported by Weiss (1971). However, the incidence of wilt disease on yield attributes at 0.6 IW/CPE ratio was not severe as was felt by adverse effect of severe soil moisture stress with 0.2 IW/CPE ratio. Hence, the extent of increase in number of capsules per plant, length of primary spike, 100

Table 1. Influence of tillage practice and irrigation schedule on stand establishment, growth and yield attributes of castor in rice fallows (1996-97 and 1997-98)

Treatment	Initial plant stand (%)		Dry matter production at harvest (g/m ²)		No. of capsules per plant		Length of primary spike (cm)		Shelling percentage (%)		100-seed weight (g)	
	96-97	97-98	96-97	97-98	96-97	97-98	96-97	97-98	96-97	97-98	96-97	97-98
<i>Tillage practices</i>												
T ₁	72.7	72.7	368.2	356.4	88	90	24.5	26.8	65.2	67.1	30.4	29.2
T ₂	85.6	85.6	462.1	447.6	102	101	31.0	32.2	71.4	73.9	31.7	30.6
T ₃	82.6	82.6	467.8	449.8	102	103	31.9	31.8	67.1	76.3	30.8	31.5
T ₄	77.6	77.6	436.3	411.9	97	95	29.2	29.2	67.3	71.1	30.3	29.4
S.E.m.±	0.3	0.3	1.3	1.9	0.6	0.5	0.3	0.2	0.6	0.2	0.2	0.1
C.D. (P=0.05)	0.9	0.9	3.8	5.7	1.8	1.6	0.8	0.6	NS	0.6	NS	0.3
<i>IW/CPE ratio</i>												
I ₁	80.0	80.0	452.6	435.9	100	99	30.1	31.6	73.7	71.9	30.7	31.3
I ₂	79.5	79.5	454.5	441.1	106	103	31.7	32.1	72.1	74.7	31.8	31.6
I ₃	79.4	79.4	393.6	372.4	86	91	25.8	26.4	58.0	69.7	30.0	27.6
S.E.m.±	0.2	0.2	0.8	0.9	0.5	0.4	0.2	0.2	0.5	0.5	0.05	0.1
C.D. (P=0.05)	NS	NS	2.2	2.6	1.4	1.3	0.6	0.6	1.5	NS	0.20	0.3

T₁ : Ploughing twice with country plough alone; T₂ : Ploughing twice with country plough followed by working twice with power tiller rotovator; T₃ : Tractor tilling with cultivator twice followed by rotovating twice with power tiller; T₄ : Tractor tilling with cultivator twice I₁ : 0.6 IW/CPE; I₂ : 0.4 IW/CPE; I₃ : 0.2 IW/CPE

seed weight and seed yield were 12, 18, 8 and 34 per cent respectively with 0.6 IW/CPE ratio over that of 0.2 ratio (Tables 1 & 2).

Irrigating the crop at 0.4 IW/CPE offered the highest net returns. The mean maximum net returns of Rs. 5394 was obtained with 0.4 IW/CPE which was higher by Rs. 1752 over 0.6 IW/CPE ratio. Negative net returns were obtained with 0.2 IW/CPE ratio (Table 2).

The interaction between tillage practices and

irrigation schedules were found to be non-significant in respect of growth, yield attributes and yield of castor.

The results of the present study clearly brought out that in sandy clay loam soils of Southern Telangana Zone of AP, for cultivation of castor after kharif rice and land should be prepared either with country plough twice or cultivator twice both followed by rotovation with power tiller and irrigated at IW/CPE ratio of 0.4.

Table 2. Influence of tillage practice and irrigation schedule on yield and economics of castor in rice fallows (1996-97 and 1997-98)

Treatment	Seed yield (kg/ha)		Oil yield (kg/ha)		Mean net returns (Rs./ha)	B : C ratio
	96-97	97-98	96-97	97-98		
<i>Tillage practices</i>						
T ₁	1150	1444	594	746	-795	0.94
T ₂	1757	1983	921	1031	4752	1.34
T ₃	1746	1999	887	1019	4601	1.32
T ₄	1634	1677	829	865	2249	1.16
S.Em.±	15	14	8	7		
C.D. (P=0.05)	47	41	23	19		
<i>IW/CPE ratio</i>						
I ₁	1672	1917	848	997	3642	1.26
I ₂	1818	1964	946	1011	5394	1.39
I ₃	1225	1447	629	738	-492	0.97
S.Em.±	8	10	8	5		
C.D. (P=0.05)	23	30	21	15		

T₁ : Ploughing twice with country plough alone; T₂ : Ploughing twice with country plough followed by working twice with power tiller rotovator; T₃ : Tractor tilling with cultivator twice followed by rotovating twice with power tiller; T₄ : Tractor tilling with cultivator twice I₁ : 0.6 IW/CPE; I₂ : 0.4 IW/CPE; I₃ : 0.2 IW/CPE

REFERENCES

- AICRP on SPCIP, 1987. All India Coordinated Research Project on Improvement of soil physical condition to increase agricultural production in problem areas. Annual Progress Report for 1986-87, Hyderabad Center pp. 29-36.
- Kumar, V. 1991. Effect of tillage and phosphorus fertilization on groundnut in rice-based cropping system M.Sc., (Ag.) thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.
- Pratibha, G. Pillai, K.G. Satyanarayana, V. and Mir Mustafa Hussain. 1994. Productivity of certain oilseeds crops as influenced by different tillage systems in rice-based cropping systems. In Prasad MVR et al. (ed) Sustainability in oilseeds. Indian Society of Oilseeds Research, Hyderabad pp. 297-301.
- Raghavaiah, C.V. 1999. Performance of castor hybrids under different levels of fertilizer in rainfed conditions in Alfisols. *Journal of Oilseeds Research*, 16(2) : 295-298.
- Weiss, E.A. 1971. Castor, Sesame and Safflower, published by Leonard Hill, London.

PLANT REGENERATION THROUGH SOMATIC EMBRYOGENESIS FROM GERMINATED SEED AND COLEOPTILE CULTURES OF FINGER MILLET

M.S. KAMBLE, B.L. DHONUKSHE, N.V. KASHID AND G.N. SHIRPURKAR

Agriculture Research Station, Niphad, Dist. Nashik, (M.S.)

ABSTRACT

From the genetic and plant improvement point of view, the ability to regenerate plants from the cell cultures means that genetic manipulations at cellular level can be evaluated in mature plants and possibly utilized in conventional breeding programme. However, the process of plantlet regeneration varied according to genotype, explant and type of medium. From the present investigation it showed that the regeneration of plants could be obtained in finger millet genotype using germinated seed calli and coleoptile calli on MS and B5 media containing BA and low levels of 2, 4-D.

Key words : Callus, genotypes, media and regeneration.

In recent years economic exploitation of callus culture technique is becoming important in variety of crops including cereals, as it has its own advantage in plant breeding. When the callus is induced in the genotype, the regenerated plants show heritable variations for both quantitative and qualitative traits, known as somaclonal variations. From the genetic and plant improvement point of view, the ability to regenerate plants from the cell cultures means that genetic manipulations at cellular level can be evaluated in mature plants and possibly utilized in conventional breeding programme. However, the process of plantlet regeneration varied according to genotype. The regenerative capacity was genetically governed and thought to be polygenic (Tomes and Smith, 1985, Higgins and Mathias 1987). Considering this object the laboratory experiment was conducted at Plant Biotechnology Unit, Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

MATERIALS AND METHODS

For the present investigation, 20 genotypes of finger millet were selected. The germinated seed and coleoptile explants are obtained from the above genotypes by inoculating the explants on Murashige and Skoog (1962) and Gamborg *et al.* (1968) B₅ medium. The media were modified by adding 2 mg/l BA and 0.25 mg/l 2, 4-D.

The viable callus obtained was sub cultured

on medium containing 0.25 mg/l 2, 4-D after 15 days from first subculture, the calli were transferred to the regeneration medium containing cytokinin and lack of 2, 4-D. In each culture tube pale yellow and greenish coloured calli (450-50 mg) were kept. For plantlet regeneration 25 ± 2°C temperature, 70% RH and illumination of 1600 lux was maintained by cool white fluorescent tube light and 8 hrs photoperiod was maintained. The experiment was carried out using factorial completely randomized design.

RESULTS AND DISCUSSION

a) Genotype × explant

The data showing per cent response of different genotypes of plantlet regeneration using germinated seed and coleoptile explant are presented in Table 1. The maximum (53.34%) plantlet regeneration was given by the genotype White ragi and IVT-23 using seed calli. In majority of the genotypes germinated seed calli were found to be most effective for plantlet regeneration.

Similar results were observed by Thiru and Ram (1980), Mohanty *et al.* (1985) and Kavikishor *et al.* (1992). The germinated seed calli which were in developmental stage given maximum per cent regeneration. This might be due to the physiological factors of explant. The embryogenically component tissues of younger



Fig. 1. Morphogenesis from calli



Fig. 2. Regeneration of plants from germinated seed calli



Fig. 3. Regeneration of plants from coleoptile calli

Table 1. Genotypic variability in relation to explants for regeneration of plantlets

Sr.No.	Genotype	Germinated Seed	Coleoptile	Mean
1	Dapoli-1	51.67 (45.97)	38.34 (38.17)	45.00 (42.07)
2	Vengurla-1	40.00 (39.23)	30.00 (33.21)	35.00 (36.22)
3	White Ragi	53.34(46.89)	40.00(30.23)	46.67(43.06)
4	Gave Local	43.34(41.15)	30.00(33.21)	36.67(37.18)
5	Dapoli-2	18.34(25.33)	36.67(37.29)	27.51(31.31)
6	AVTE-1	18.08(25.10)	20.00(26.56)	19.04(25.83)
7	AVTE-3	26.67(31.11)	40.00(39.23)	33.34(35.17)
8	AVTE-6	45.00(42.13)	50.00(39.23)	42.50(40.68)
9	AVTE-9	31.67(34.27)	25.00(30.00)	28.34(32.14)
10	AVTM-4	43.34(41.15)	30.00(33.21)	36.67(37.18)
11	AVTM-6	25.00(30.00)	30.00(33.21)	27.51(31.61)
12	AVTM-10	36.67(37.29)	45.00(42.13)	40.84(39.71)
13	AVTL-6	45.00(42.13)	36.67(37.29)	40.84(39.71)
14	AVTL-8	41.67(40.22)	36.67(37.29)	39.17(38.76)
15	IVT-10	45.00(42.13)	40.00(39.23)	42.50(40.68)
16	IVT-18	28.34(32.14)	20.00(26.51)	24.17(29.33)
17	IVT-20	41.67(40.22)	36.67(37.29)	39.17(38.76)
18	IVT-23	53.34(46.89)	41.67(40.22)	47.51(43.56)
19	IVT-26	33.34(35.24)	28.34(32.14)	30.84(33.69)
20	IVT-28	41.67(40.22)	21.67(27.76)	31.67(33.99)
	Mean	38.16(37.94)	33.34(35.12)	35.75(36.53)
	Range	18.08(25.10)	23.00(26.56)	19.04(25.83)
		to	to	to
		53.34 (46.89)	45.00 (42.13)	47.51 (43.56)
	Genotype		Explant	Genotype × Explant
	SE±	1.758	0.556	0.786
	C.D.	4.272	1.541	2.179

(Figures in parenthesis indicate arc-sin values)

explant contain high level of IAA and IBA which help for regeneration. This suggested that, explants had significant effect on regeneration

of plantlets. Thiru and Ram (1980), Eapen and George (1989) also observed the variable response due to effect of explant calli for plantlet

Table 2. Genotypic response in relation to media for regeneration of plantlets

Sr.No.	Genotype	MS	B ₅	Mean
1	Dapoli-1	33.34(35.24)	56.67(48.85)	45.00(40.05)
2	Vengurla-1	25.00(30.00)	45.00(42.13)	35.00(36.07)
3	White Ragi	41.67(40.22)	51.67(56.97)	46.67(40.10)
4	Gave Local	33.34(35.24)	40.00(39.23)	36.67(37.24)
5	Dapoli-2	28.34(32.14)	26.67(31.11)	27.51(31.63)
6	AVTE-1	14.75(22.63)	23.34(28.86)	19.05(25.75)
7	AVTE-3	26.67(31.11)	40.00(39.23)	33.34(35.17)
8	AVTE-6	48.34(44.03)	36.67(37.29)	42.51(40.66)
9	AVTE-9	35.00(36.27)	21.67(27.76)	28.34(32.02)
10	AVTM-4	41.67(40.22)	31.67(34.27)	36.67(37.25)
11	AVTM-6	31.67(34.27)	23.34(28.86)	27.51(31.57)
12	AVTM-10	20.00(26.56)	61.67(51.77)	40.84(39.17)
13	AVTL-6	45.00(42.13)	36.67(37.29)	40.84(39.71)
14	AVTL-8	50.00(45.00)	28.34(32.14)	39.17(38.57)
15	IVT-10	36.67(37.29)	48.34(44.03)	42.51(40.66)
16	IVT-18	13.34(21.39)	35.00(36.27)	24.17(28.83)
17	IVT-20	53.34(46.89)	25.00(30.00)	39.17(38.45)
18	IVT-23	38.34(38.17)	56.67(48.85)	47.51(43.51)
19	IVT-26	23.34(28.86)	38.34(38.17)	30.84(33.52)
20	IVT-28	28.34(32.14)	35.00(36.27)	31.67(34.21)
	Mean	33.40(34.99)	38.08(37.92)	35.75(36.45)
	Range	13.34(21.39)	21.67(27.76)	19.05(25.75)
		to	to	to
		53.34(46.89)	61.67(51.77)	47.51(43.51)
		Genotype	Medium	Genotype × Medium
	SE±	1.758	0.556	2.486
	C.D.	4.872	1.541	6.890

(Figures in parenthesis indicate arc-sin values)

Table 3. Genotypic × Explant × Medium interaction for regeneration of plantlets

Sr.No.	Genotype	Germinated Seed		Coleoptile	
		MS	B ₅	MS	B ₅
1	Dapoli-1	43.33(41.15)	60.00(50.77)	23.33(28.86)	43.33(41.15)
2	Vengurla-1	33.33(35.24)	66.66(54.76)	16.11(23.73)	43.33(41.15)
3	White Ragi	53.33(46.89)	53.33(46.89)	33.00(33.21)	50.00(45.00)
4	Gave Local	40.00(39.23)	46.66(43.11)	26.66(31.11)	33.33(35.24)
5	Dapoli-2	20.00(26.56)	16.66(24.12)	36.66(37.29)	36.66(37.29)
6	AVTE-1	16.66(24.12)	20.00(26.56)	13.33(21.39)	26.66(31.11)
7	AVTE-3	20.00(26.56)	33.33(35.24)	33.33(35.24)	46.66(43.11)
8	AVTE-6	50.00(45.00)	40.00(39.23)	46.66(43.11)	43.33(35.24)
9	AVTE-9	50.00(45.00)	26.66(31.11)	33.33(35.24)	16.66(24.12)
10	AVTM-4	53.33(46.89)	33.33(35.24)	30.00(33.21)	30.00(33.21)
11	AVTM-6	23.33(28.86)	26.66(31.11)	40.00(39.23)	20.00(26.56)
12	AVTM-10	16.66(24.12)	56.66(48.85)	23.33(28.86)	66.66(54.76)
13	AVTL-6	46.66(43.11)	43.33(41.15)	43.33(41.15)	30.00(33.21)
14	AVTL-8	53.33(46.89)	30.00(33.21)	46.66(43.11)	26.66(31.11)

contd...

Table 3 contd...

15	IVT-10	40.00(39.23)	50.00(45.00)	33.33(35.24)	46.66(43.11)
16	IVT-18	16.66(24.12)	40.00(39.23)	10.00(18.44)	30.00(33.21)
17	IVT-20	63.33(52.71)	20.00(26.56)	43.33(41.15)	30.00(33.21)
18	IVT-23	40.00(39.23)	66.66(54.74)	36.66(37.29)	46.66(43.11)
19	IVT-26	23.33(28.86)	43.33(41.15)	23.33(28.86)	33.33(35.24)
20	IVT-28	36.66(37.29)	46.66(43.11)	20.00(26.56)	23.33(28.86)
	Mean	37.00(37.05)	41.00(39.56)	30.47(33.14)	35.64(36.45)
	Range	16.66(24.12)	16.66(24.12)	10.00(18.44)	16.66(24.12)
		to	to	to	to
		63.33(52.71)	66.66(54.76)	46.66(43.11)	66.66(54.76)
	Genotype $\times$ Explant $\times$ Media				
		SE $\pm$	3.515		
		C.D.	N.S.		

(Figures in parenthesis indicate arc-sin values)

regeneration.

b) Genotype $\times$ media

The data showing per cent response of different genotypes to plantlet regeneration using different media are presented in Table 2. The B5 medium had given highest (61.67%) plantlet regeneration with AVTM-10 genotype while lowest (13.35%) was recorded by IVI-18 genotype in MS medium. The MS and B5 media were used for organogenesis by adding cytokinin and auxin. Callus induction is governed by types of explant, media and concentration of 2, 4-D (Tomes and Smith, 1985). The genotype of the donor plant is the most important factor in the finger millet. In the present investigation Dapoli-1 proved to be best for callus induction (59.80-78.13%).

c) Genotype $\times$ explant $\times$ medium

From the Table 3 it is observed that the interaction differences between genotype, explant and medium were highly significant for plantlet regeneration. The treatment

combinations of germinated seed calli of genotype Vengurla-1 and IVT-23 and coleoptile calli of genotype AVTM-10 in B5 medium, while coleoptile derived calli of Dapoli-2 genotype regenerated maximum plantlets equally in MS and B5 medium.

A wide range of variability was observed for per cent response of genotypes for per cent response to regeneration. The morphogenic potential of two explants was also different. The germinated seed calli gave maximum per cent plantlet regeneration on B5 medium. The treatment combination of germinated seed calli in Vengurla-1 and IVT-23 genotypes, coleoptile calli in AVTM-10 genotype with B5 medium were more effective for plantlet regeneration.

From the present investigation it could be concluded that the regeneration of plants could be obtained in finger millet genotype using germinated seed calli and coleoptile calli on MS and B₅ media containing BA.

REFERENCES

- Eapen, S. and George, L. 1989. High frequency plant regeneration through somatic embryogenesis in finger millet (*Eleusine caracana* Gaertn.). *Plant Sci.*, **61** : 127-130.
- Gamborg, O.L., Miller, R.A. and Ojima, K. 1968. Nutrient requirements of suspension cultures of soybean root cells. *Exp. Cell. Res.*, **50** : 148-151.
- Higgins, P. and Mathias, R.J. 1987. The effect of the 4 B chromosomes of hexaploid wheat on the growth and regeneration of callus cultures. *Theor. Appl. Genet.* **74** : 439-444.
- Kavi Kishor, P.B., Rao, A.M. Dhar, A.C. and Naidu, K.R. 1992. Plant regeneration in tissue cultures of some millets, *Indian J. Expt. Biol.*, **30** : 729-733.
- Mohanty, B.D. Dutta Gupta, S. and Ghosh, P.D. 1985. Callus initiation and plantlet regeneration in ragi

- (*Eleusine coracana*). *Plant Cell. Tissue and Organ Culture*, 5 : 147-150.
- Murashige, T. and Skoog, F. 1962. A revised medium for rapid growth and bio-assay with tobacco tissue cultures. *Physiol. Plant.* 15 : 473-497, Variability pattern and its impact on the structure of yield in ragi. University of Agricultural Sciences, Bangalore.
- Thiru, N.A. and Ram, M.H.Y. 1980. Tissue culture studies on ragi (*Eleusine coracana* Gaertn.) *Indian J. Expt. Biol.*, 18 : 1110-1113.
- Tomes, D.T. and Smith, O.S. 1985. The effect of parental genotype on initiation of embryogenic callus from elite maize germplasm. *Theor. Appl. Genet.*, 70 : 505-509.

INFLUENCE OF PLANTING RATIO AND FERTILIZER APPLICATION ON DRY MATTER PRODUCTION LAI AND NUTRIENT CONTENT AND UPTAKE BY MAIZE (*ZEA MAYS*) AND GROUNDNUT (*ARACHIS HYPOGAEA*) IN INTERCROPPING

ARVIND KUMAR, S.N. SINGH AND GAJENDRA GIRI

*Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Experiments revealed that maize and groundnut accumulated significantly more dry matter when grown in 1:1 ratio. However, N and P content and their uptake by maize was not influenced by planting ratio. Whereas groundnut removed more N and P in 1:2 ratio of planting. Application of 100% recommended doses of fertilizers to both maize and groundnut recorded significantly higher dry matter and resulted into more uptake of N and P by maize and groundnut. However, N uptake by maize and groundnut due to 75+100 and 100+100% doses of fertilizer applied to component crops remained on par. This indicated the saving of 25% dose of N to maize in association with groundnut.

Key words : Drymatter, nutrient uptake, planting ratio, intercropping, maize and groundnut.

The productivity from intercropping system is governed by canopy management which is the output of compatibility between component crops and nutrient management. Harmony between the crops grown in association, therefore, becomes the decisive factor for dry matter production. Maize and groundnut has been advocated to be a profitable combination of intercropping. But their planting ratio still needs to be standardized. At the same time, fertilizer recommendation for the system has not been worked out, however, information on the nutrient needs of both the crops in isolation is in abundance. Keeping this fact in view the present investigation was carried out to study the effect of planting patterns and N and P fertilization on dry-matter accumulation, N and P content and uptake by component crops.

MATERIALS AND METHODS

An experiment was conducted at the Division of Agronomy, IARI, New Delhi during kharif (rainy) seasons of 1999 and 2000. The experiment was conducted in split plot design with three replications keeping planting ratio (1:1 and 1:2 ratio of maize and groundnut) in main plots and fertilizer combination (100+100%, 100+75%, 100+50%, 75+100%, 75+75%, 75+50%,

50+100%, 50+75% and 50+50% of recommended dose for maize and groundnut, respectively) in sub plots. Maize cv. Ganga Safed 2 and groundnut cv. SG 84 were sown on 4 and 5 July in respective years. Maize sown in rows at 75 cm apart was intercropped with one or two rows of groundnut as per treatment. The recommended doses for maize were 120 kg N and 60 kg P₂O₅ and for groundnut were 20 kg N and 50 kg P₂O₅/ha. A uniform dose of 40 kg K₂O and 25 kg ZnSO₄ was supplied to maize crop. Four irrigations were given in each year to meet the water need of the crops.

RESULTS AND DISCUSSION

Effect of planting ratio

Maize : Results (Table 1) showed that planting ratio did not bring any change in leaf area index of maize. However, 1:1 ratio of planting accumulated significantly more dry matter at later stages of maize growth. This could be because low groundnut population in 1:1 ratio made more space available to maize plants than in 1:2 ratio which might have helped maize plant in exploitation of neutral resources more efficiently and resulted into more dry matter accumulation at later stage. This observation is in agreement with those of Shivay *et al.* (1999).

Results (Table 3) showed that planting ratio did not influence N and P content in grain and stover in two years of experimentation. The total uptake of N and P also remained almost similar under both the planting patterns because yield remained constant (Fig. 1).

Groundnut : Groundnut in 1:2 ratio of planting ratio resulted into significantly higher leaf area index at 90 days only (Table 2). This was because of higher plant density of groundnut in 1:2 ratio. But dry matter was more in 1:1 ratio, however, difference was significant at 60 days. This was because lower groundnut population in 1:1 ratio might have offered less interplant competition. Hence, plant might have utilized the natural resources more efficiently to produce more dry matter in 1:1 ratio of planting.

The data (Table 4) pointed out that 1:2 ratio of planting ratio recorded higher N content in kernel and stover. But the difference was significant for kernel only. Similarly, P content in kernel and stover was numerically higher with 1:2 ratio of planting. The total uptake of N and P was significantly higher in 1:2 ratio because in this system, plant population was double of the 1:1 ratio which registered significantly higher kernel and stover yield (Fig. 2). This led to the higher N and P uptake by groundnut. in 1:2 ratio of planting pattern.

Effect of N and P application

Maize : Application of 100% dose of fertilizers to maize recorded highest leaf area and dry matter at all the stages (Table 1). These were significantly reduced when fertilizer dose was reduced to maize. Thus, 50% doses of fertilizers recorded lowest LAI and drymatter. Application of fertilizer to groundnut did not make much difference in drymatter production of maize. However, reduction in dose of fertilizer from 100 to 75% to groundnut under 75% dose of maize brought significant reduction in drymatter. This may be ascribed to the fact that application of recommended dose of fertilizers helped in better growth which was manifested in more leaf area. This ensured more sunlight interception and high photosynthesis which ultimately led to higher dry matter accumulation (Aujla *et al.* 1987).

Fertilizer application significantly influenced the nitrogen and phosphorus content in grain and stover of maize during both the years (Table 2). The highest nitrogen content in grain and stover was recorded with 100% of recommended dose of fertilizers which was significantly reduced to lowest with 50% of recommended dose. However, 75% dose remained statistically on par with 100% dose to maize in respect of N content in stover. Application of 100% of recommended dose of fertilizer to maize recorded significantly higher P content in grain as well as in stover than rest of combinations. However, P content in grain under 100 and 75% dose remained on par. It is worth to note that P content in stover with 75+50% dose to component crops remained statistically on par with 100+50% recommended doses of fertilizers.

Recommended dose of fertilizer registered higher uptake of N and P by maize which was significantly reduced with 50% of recommended dose of fertilizer. However, total N uptake recorded with 100+100% of fertilizer dose was statistically on par with 75+100% of fertilizer to respective crops in intercropping. Increase in N and P uptake under higher dose of fertilizer was due to the fact that recommended dose of fertilizers favoured drymatter production (Table 1) and yield (Fig. 1) which in turn removed more nutrients. As a result of higher content, more uptake of nutrients was registered with higher doses of fertilizer applied to maize.

Groundnut : Different combinations of fertilizer influenced the LAI of groundnut but 100+100% dose of N and P applied to maize and groundnut, respectively recorded the highest LAI. This may be ascribed to the favourable effect of N and P on growth of groundnut. As a result of interception of more sunlight, more photosynthesis per unit area might have taken place (Table 2). Groundnut produced significantly higher drymatter at all the stages when 100% fertilizer was applied. Reduction in fertilizer dose produced lower drymatter. AT 30 DAS, the highest drymatter was recorded when 50 and 100% of recommended dose of fertilizers was applied to the maize and groundnut crops, respectively. This finding is in

Table 1. Dry matter accumulation and leaf area index of maize as affected by planting ratio and fertilizer application (pooled for two years)

Treatments	Dry matter accumulation (g/plant)			Leaf area index (LAI)		
	Days after sowing					
	30	60	90	30	60	90
Planting pattern						
1:1 ratio	21.02	90.28	140.8	1.11	1.55	2.24
1:2 ratio	20.12	85.94	133.0	1.03	1.53	2.25
C.D. (P=0.05)	NS	3.80	4.7	NS	NS	NS
Fertilizer combination						
100+100%	29.25	118.45	190.0	1.33	1.95	2.81
100+75%	30.23	117.68	189.3	1.29	1.83	2.65
100+50%	27.77	115.35	186.5	1.28	1.81	2.64
75+100%	20.46	84.83	131.1	1.16	1.64	2.40
75+75%	19.35	80.00	118.7	1.12	1.68	2.43
75+50%	19.02	79.60	118.6	1.12	1.60	2.34
50+100%	14.04	66.00	100.9	0.81	1.13	1.66
50+75%	13.91	66.08	99.2	0.77	1.07	1.63
50+50%	13.59	65.01	98.3	0.74	1.11	1.67
C.D. (P=0.05)	0.90	2.82	3.1	0.10	0.06	0.07

Table 2. Dry matter accumulation and leaf area index of groundnut as influenced by planting ratio and fertilizer application (pooled for two years)

Treatments	Dry matter accumulation (g/plant)			Leaf area index (LAI)		
	Days after sowing					
	30	60	90	30	60	90
Planting pattern						
1:1 ratio	2.58	4.86	8.67	0.235	0.315	0.985
1:2 ratio	2.53	4.72	8.44	0.215	0.290	1.045
C.D. (P=0.05)	NS	0.05	NS	NS	NS	0.020
Fertilizer combination						
100+100%	2.71	5.10	9.11	0.265	0.355	1.205
100+75%	2.54	4.98	8.50	0.235	0.315	1.120
100+50%	2.45	4.60	8.10	0.190	0.250	1.045
75+100%	2.67	4.96	8.86	0.320	0.425	1.070
75+75%	2.49	4.76	8.45	0.285	0.385	1.005
75+50%	2.42	4.58	8.11	0.195	0.260	0.950
50+100%	2.74	5.06	9.21	0.195	0.265	1.040
50+75%	2.53	4.74	8.46	0.185	0.255	0.940
50+50%	2.45	4.50	8.10	0.170	0.225	0.740
C.D. (P=0.05)	0.02	0.11	0.36	0.010	0.020	0.06

accordance with Rajendran and Lourduraj (1998) and Giridhar and Giri (1990).

The highest N content in kernel was observed when 50% of recommended dose of fertilizer was applied to groundnut irrespective

of fertilizer dose applied to maize. Increase in fertilizer dose to groundnut brought significant reduction in N content in groundnut kernel. Thus, 100% dose of fertilizer recorded lowest N content. Whereas, application of 100% fertilizer dose to groundnut recorded lowest N content.

Table 3. Effect of planting ratio and fertilizer application of N and P content and uptake of maize in intercropping (pooled for two years)

Treatments	N content		P content		Total uptake (kg/ha)	
	Grain	Stover	Grain	Stover	N	P
Planting pattern						
1:1 ratio	1.41	0.60	0.30	0.38	93.3	37.2
1:2 ratio	1.41	0.61	0.30	0.39	95.3	37.7
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Fertilizer combination						
100+100%	1.50	0.63	0.32	0.42	104.4	43.0
100+75%	1.50	0.64	0.32	0.41	107.5	41.8
100+50%	1.50	0.63	0.31	0.40	105.5	42.3
75+100%	1.44	0.63	0.30	0.39	103.9	39.6
75+75%	1.45	0.61	0.30	0.36	99.4	39.2
75+50%	1.43	0.60	0.30	0.38	87.8	36.1
50+100%	1.30	0.58	0.28	0.39	82.3	31.9
50+75%	1.30	0.58	0.28	0.37	79.4	31.9
50+50%	1.29	0.57	0.26	0.35	78.2	31.0
C.D. (P=0.05)	0.02	0.03	0.02	0.02	10.7	2.5

Table 4. N and P content and total uptake by groundnut as affected by planting ratio and fertilizer combinations (pooled for two years)

Treatments	N content		P content		Total uptake (kg/ha)	
	Kernel	Stover	Kernel	Stover	N	P
Planting pattern						
1:1 ratio	4.22	0.73	0.31	0.21	40.4	5.1
1:2 ratio	4.32	0.77	0.32	0.23	59.4	8.3
C.D. (P=0.05)	0.006	NS	NS	NS	8.9	0.8
Fertilizer combination						
100+100%	4.18	0.79	0.35	0.26	52.6	8.1
100+75%	4.30	0.75	0.32	0.23	50.0	6.8
100+50%	4.33	0.70	0.29	0.21	45.4	5.6
75+100%	4.20	0.78	0.33	0.24	54.3	7.5
75+75%	4.30	0.76	0.31	0.22	49.2	6.4
75+50%	4.33	0.72	0.28	0.20	45.1	5.5
50+100%	4.20	0.78	0.33	0.24	57.2	8.1
50+75%	4.29	0.74	0.31	0.21	50.4	6.5
50+50%	4.31	0.71	0.28	0.19	44.6	5.4
C.D. (P=0.05)	0.02	0.03	0.02	0.01	3.4	0.3

Whereas, application of 100% fertilizer dose to groundnut recorded highest nitrogen content in stover of groundnut irrespective of fertilizer dose applied to maize. Reduction in fertilizer dose to groundnut significantly reduced the N content in stover (Table 4). Application of 100% of recommended dose of fertilizer applied to groundnut under different doses to maize

recorded highest P content both in kernel and stover of groundnut (Table 4).

Application of 50+100% doses of fertilizers being on par with 100+100% doses and 75+100% to maize and groundnut, respectively, recorded highest uptake of N by groundnut. The lowest N uptake was recorded with 50% doses supplied

to both crops. The total uptake of phosphorus by groundnut was highest when crop was supplied with 100% dose of fertilizers under different dose of fertilizers to maize. Application of 50% of recommended dose recorded lowest P uptake. This was because of the fact that better nutrition due to higher dose of fertilizer might

have ensured availability of nutrients which improved nutrient absorption by plants. Thus, the higher content of nutrients in plant parts and increase in yield (Fig. 2) resulted into more uptake of N and P under 100% dose of fertilizers. These findings are in accordance with Giridhar and Giri (1990) and Patel and Patil (1990).

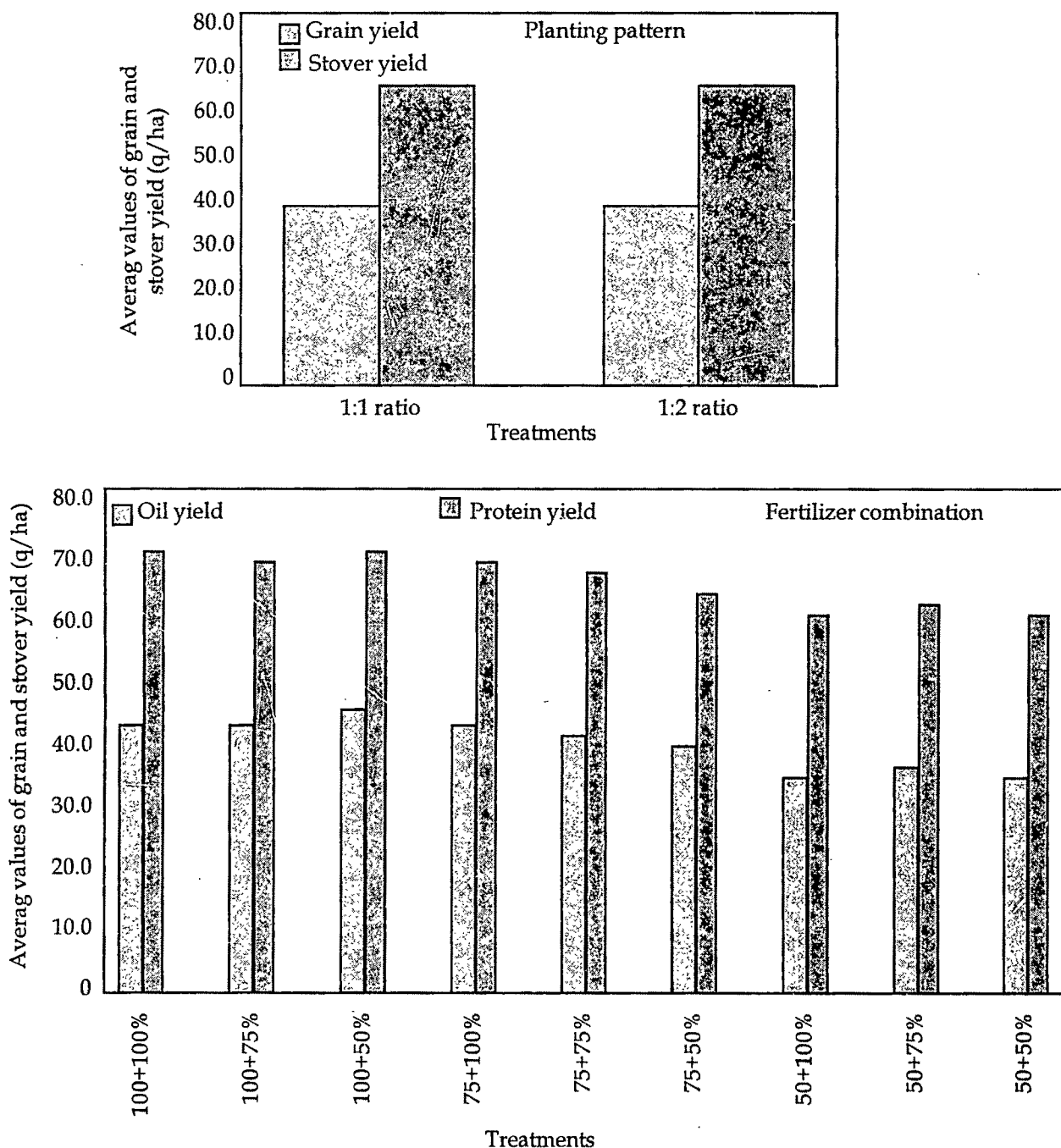


Fig. 1. Effect of planting pattern and fertilizer combination on grain and stover yield of maize crop

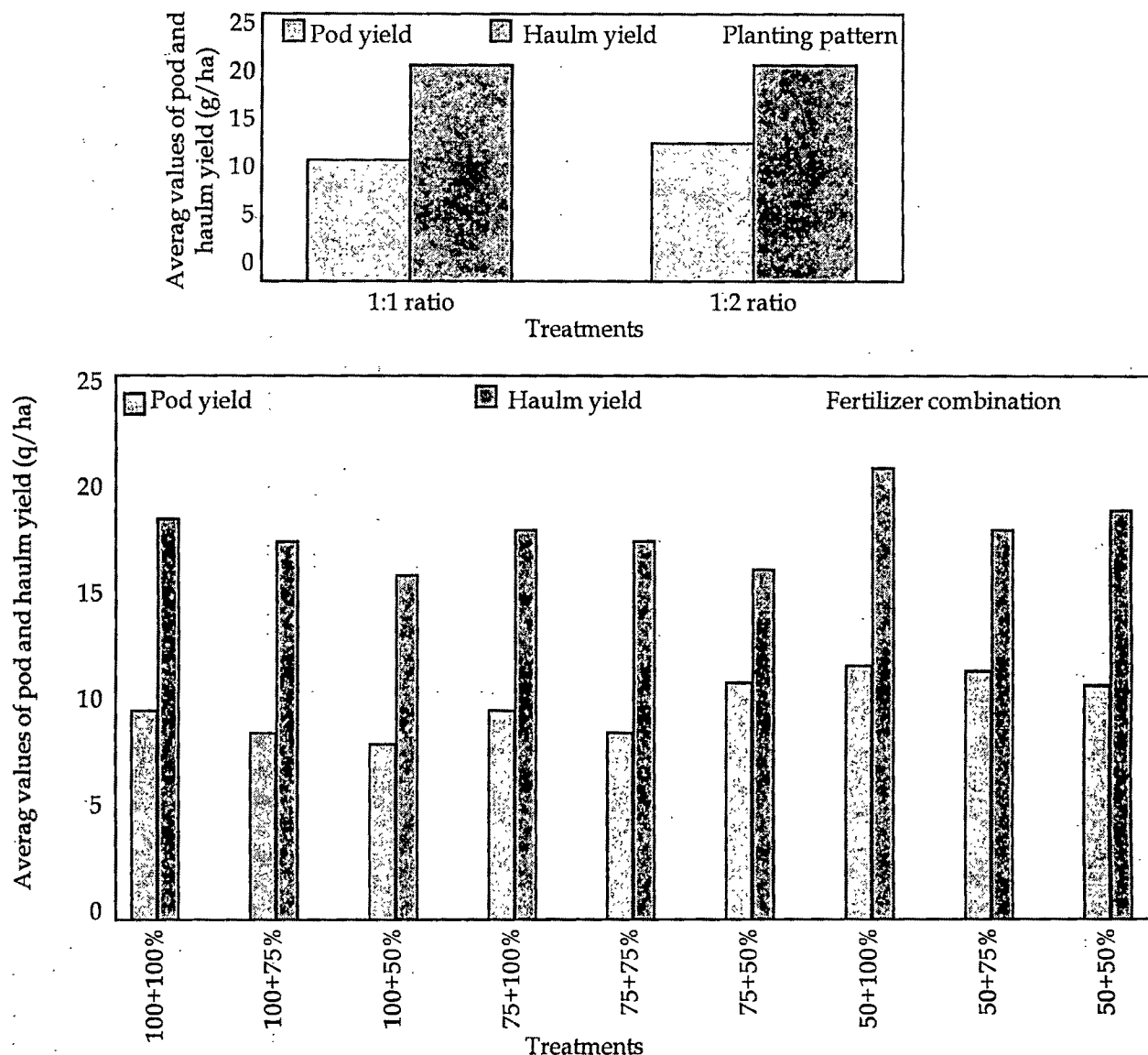


Fig. 2. Effect of planting pattern and fertilizer combination on pod and haulm yield of groundnut.

REFERENCES

- Aujla, T.S., Sandhu, B., Singh, G., Singh Baldev and Khera, K.L. 1987. Irrigation, N-fertilization and straw mulch effect on growth and yield of winter maize on a sandy loam soil in Punjab. *Journal of Research Punjab Agricultural University*, **24** : 563-674.
- Giridhar, Kandalam and Giri, Gajendra, 1990. Drymatter accumulation and nutrient uptake of groundnut varieties as influenced by chlormequat chloride and phosphorus doses. *Annals of Agricultural Research*, **20**(1) : 30-34.
- Patel, M.S. and Patil, R.G. 1990. Effect of different levels of phosphorus and zinc on yield and nutrient uptake of groundnut and maize (fodder). *Gujarat Agricultural University Research Journal*, **16**(1) : 63-66.
- Rajendran, K. and Lourduraj, A.C. 1998. Response of groundnut (*Arachis hypogaea* L.) to nitrogen and phosphorus nutrition - a review, *Agricultural Reviews, Karnal*, **19**(2) : 137-139.
- Shivay, Y.S., Singh, R.P. and Pandey, C.S. 1999. Response of nitrogen to maize (*Zea mays*) based intercropping system. *Indian Journal of Agronomy*, **44**(2) : 261-266.

EFFECT OF INTEGRATED NUTRIENT SUPPLY ON GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM*)

SUMAN MEHTA

Division of Agronomy

Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu, R.S. Pura - 181 102, Jammu

ABSTRACT

An experiment was conducted during winter season of 2001-02 on clay loam soil at SKUAST-J, R.S. Pura to study the effect of organic residues [FYM@5 t ha⁻¹ on oven dry weight basis, *Leucaena* (Ls) and paddy straw (Ps)] and different doses of chemical fertilizers [50, 100 (100 kg N, 50 kg P₂O₅ and 40 kg K₂O ha⁻¹) and 150% of recommended dose (RFD)] in combination with each other, on wheat. Conjunctive use of FYM @ 2.5 t ha⁻¹ + Ls with 150% RFD significantly produced taller plants, higher dry matter accumulation, more number of effective tillers and increased the number of days taken for 75% heading and maturity. Similarly, application of FYM @ 2.5 t ha⁻¹ + Ls + 150% RFD resulted in significant higher grain and straw yield of wheat. However, these results remains at par with those recorded with the application of FYM @ 5 t ha⁻¹ + 150% RFD and Ls + 150% RFD.

Key words : Wheat, integrated nutrient supply, growth, development, yield.

Integrating chemical fertilizers with organic manures has been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production (Nambiar and Abrol, 1992). Farmyard manure (FYM) is being use as a major source of organic manure in field crops. Limited availability of this manure is however, an important constraint in its use as a source of nutrients. It is, therefore, desirable to integrate the readily available organic residues at farmer's field like *Leucaena* (Ls) and paddy straw (Ps), which go out of the agro-ecosystem, merely as waste products. The present study was therefore undertaken to find out the effect of integration of different doses of chemical fertilizers with various organic residues.

MATERIALS AND METHODS

Field experiment was conducted at Research Farm of the SKUAST-J, R.S. Pura during winter season of 2001-02. The soil of field was clay loam in texture belonging to the order inceptisol, neutral in reaction (pH 6.64), normal in electrical conductivity (0.08 dS m⁻¹), medium in organic carbon (0.46%), low in available nitrogen (218.4 kg ha⁻¹), medium in available phosphorus (16.57 kg ha⁻¹) and low in available potassium (100.8

kg ha⁻¹). The experiment was laid out in randomized block design with 3 replications. The treatments consisted of all possible combinations of three doses of inorganic fertilizers viz. 50, 100 (100 kg N-50 kg P₂O₅ - 40 kg K₂O ha⁻¹) and 150% of recommended fertilizer dose (RFD) and five organic sources viz. FYM @ 5 t ha⁻¹ on oven dry weight bases, *Leucaena* biomass (Ls), paddy straw (Ps), FYM @ 2.5 t ha⁻¹ + Ls and FYM @ 2.5 t ha⁻¹ + Ps. The quantities of Ls and Ps when applied alone were decided on the basis of the equivalent amount of N supplied by 5 t FYM ha⁻¹ whereas, their quantities were reduced to half when they were applied in combination with 2.5 t ha⁻¹ FYM. These organic residues were incorporated as per the treatment one day before the sowing of wheat crop. Half of the nitrogen in the form of urea and full doses of phosphorus and potassium as per treatment were applied at the time of sowing and remaining half nitrogen was top dressed in two equal splits, one at 30 days and the other at 60 days after sowing. The sowing and harvesting of wheat var. PBW-343 was done on 19th October, 2001 and 9th May, 2002; respectively. All other operations were performed as per the recommendations for the crop. Observations on growth and yield were recorded at harvest Days taken to 75% heading

and maturity were calculated from the day of first appearance of ear and sowing, respectively.

RESULTS AND DISCUSSION

Growth and development characters

The results (Table 1) revealed that plant height of wheat increased significantly in the treatments where 150% RFD was applied in combination with FYM and/or Ls or Ps (T_{13} , T_4 , T_7 , T_{16} and T_{10}) along with the treatments where 100% RFD was clubbed with FYM and/or Ls (T_{13} , T_{12} and T_6). Other growth parameters viz. dry matter accumulation and effective tillers per square meter increased significantly with the application of 150% RFD in combination with FYM and/or Ls (T_{13} , T_4 and T_7) as compared to other treatments. Overall, taller plant (81.85 cm), higher dry matter (1021.6 g m^{-2}) and more number of effective tillers (281.5 m^{-2}) were recorded in treatment T_{13} . This might have happened due to the fact that a part of fertilizer might have got immobilized in residue

incorporated plots and hence crop required more nitrogen which was compensated in the treatments where 150% RFD was applied. These results are in close conformity with those reported by Peer (1997).

The application of treatment T_{13} significantly increased the number of days taken to 75% heading (32.19) and maturity (154.0). However, it was found to be at par with those observed under the conjunctive use of FYM or Ls or Ps with 150% RFD i.e. in treatments T_4 , T_7 and T_{16} (Table 1). This might have happened due to the continuous supply of nitrogen to plants where higher balanced doses of NPK (150% RFD) were applied.

Grain and straw yield

Incorporation of FYM @ 2.5 t ha^{-1} alongwith Ls and 150% NPK gave significantly higher grain yield of 42.29 q ha^{-1} which was found to be statistically at par with those recorded under treatments T_4 and T_7 with yield levels of 40.41

Table 1. Effect of INM treatments on plant height, dry matter accumulation, effective tillers, days taken to 75% heading and maturity by wheat crop

Treatments	Plant height (cm)	Dry matter accumulation (m^{-2})	No. of effective tillers (m^{-2})	Days taken to 75% heading	Days taken to maturity
T_1 = Control	53.13	550.8	241.2	19.70	146.0
T_2 = FYM (5t) + 50% RFD	71.47	695.2	249.3	22.16	149.3
T_3 = FYM (5t) 100% RFD	77.10	843.7	266.4	27.45	152.6
T_4 = FYM (5t) 150% RFD	80.12	1014.3	276.8	31.27	153.2
T_5 = Ls + 50% RFD	71.24	657.7	248.5	21.98	148.7
T_6 = Ls + 100% RFD	75.10	800.1	257.9	26.39	152.0
T_7 = Ls + 150% RFD	79.32	1004.4	274.0	30.96	153.0
T_8 = Ps + 50% RFD	66.36	604.5	248.3	20.86	147.6
T_9 = Ps + 100% RFD	72.12	742.9	254.0	23.75	149.8
T_{10} = Ps + 150% RFD	76.38	824.7	258.9	27.43	152.4
T_{11} = FYM (2.5 T) + Ls + 50% RFD	72.74	745.7	254.4	23.72	150.0
T_{12} = FYM (2.5 T) + Ls + 100% RFD	75.95	809.1	259.6	26.94	152.0
T_{13} = FYM (2.5 T) + Ls + 150% RFD	81.85	1021.6	281.5	32.19	154.0
T_{14} = FYM (2.5 T) + Ps + 50% RFD	68.13	623.35	248.8	21.98	148.6
T_{15} = FYM (2.5 T) + Ps + 100% RFD	73.62	765.8	256.8	26.65	150.6
T_{16} = FYM (2.5 T) + Ps + 150% RFD	77.49	876.8	265.7	30.77	152.9
LSD ($P = 0.05$)	7.2	80.47	9.67	1.42	1.30

and 39.37 q ha⁻¹ (Table 2). Straw yield also followed similar trend. This was probably due to the fact that balanced application of NPK at higher levels in combination with narrow C : N ratio organic residues might have favorably influenced the plant growth and development which was ultimately depicted in higher yield. However, nutrient management treatments in general did not bring about any significant

changes in harvest index values. Almost similar results were reported by Rajender *et al.* (1997) and Singh and Sharma (2000).

Thus, it can be inferred from the present study that application of higher balanced dose of NPK (150% RFD) in combination with narrow C : N ratio organic residues (FYM and/or Ls) resulted in significant improvement in growth, growth span, grain and straw yield of wheat.

Table 2. Effect of INM treatments on grain yield, straw yield and harvest index of wheat

Treatments	Yield (q/ha ⁻¹)		Harvest index (%)
	Grain	Straw	
T ₁ = Control	22.62	41.18	35.44
T ₂ = FYM (5t) + 50% RFD	27.16	45.84	37.20
T ₃ = FYM (5t) 100% RFD	34.17	57.21	37.38
T ₄ = FYM (5t) 150% RFD	40.41	63.43	38.92
T ₅ = Ls + 50% RFD	25.79	44.74	36.56
T ₆ = Ls + 100% RFD	32.33	56.29	36.48
T ₇ = Ls + 150% RFD	39.37	62.00	38.83
T ₈ = Ps + 50% RFD	23.29	43.22	36.65
T ₉ = Ps + 100% RFD	29.50	50.41	36.91
T ₁₀ = Ps + 150% RFD	33.46	56.67	37.10
T ₁₁ = FYM (2.5 T) + Ls + 50% RFD	29.71	50.86	36.87
T ₁₂ = FYM (2.5 T) + Ls + 100% RFD	32.79	56.44	36.74
T ₁₃ = FYM (2.5 T) + Ls + 150% RFD	42.29	63.84	39.83
T ₁₄ = FYM (2.5 T) + Ps + 50% RFD	24.96	43.68	36.35
T ₁₅ = FYM (2.5 T) + Ps + 100% RFD	30.75	52.70	36.82
T ₁₆ = FYM (2.5 T) + Ps + 150% RFD	35.71	58.58	37.87
LSD (P = 0.05)	2.99	2.47	NS

REFERENCES

- Nambiar, K.K.M. and Abrol, I.P. 1992. Long-term fertilizer experiments in India - An overview. *Fertilizer News*, 34(4) : 11-26.
- Peer, A.C. 1997. Studies on integrated nutrient management in wheat under irrigated conditions. M.Sc. thesis, Sher-e-Kashmir University of Agricultural Sciences and Technology, R.S. Pura, Jammu.
- Rajender, Kumar, Sanjeev Kumar, Kumar, R. and Kumar, S. 1997. Integrated nutrient management for sustained wheat (*Triticum aestivum*) production in sandy loam soils of Haryana. *Annals of Biology, Ludhiana*, 132(1) : 27-9.
- Singh, M. and Sharma, S.N. 2000. Effect of wheat residue management practices and nitrogen rates on productivity and nutrient uptake of rice (*Oryza sativa*) - wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agricultural Sciences*, 70 (12) : 835-39.

THE SOCIO-ECONOMIC, COMMUNICATION AND PSYCHOLOGICAL CHARACTERISTICS OF THE SORGHUM GROWERS IN VIDHARBHA REGION IN MAHARASHTRA

V.N. KARDAK, N.V. KASHID, M.S. KAMBLE AND S.N. KARDAK

*Agriculture Research Station
Niphad, Dist. Nashik, M.S.*

ABSTRACT

The area under sorghum in Vidharbha region decreasing due to socio-economic, communication and psychological characteristics of the sorghum growers as a higher percentage of the respondents (30.00%) were found to be educated upto only high school. More than one third of the respondents (39.33%) belonged to medium land holding category of 10.01 to 25.0 acre. The majority of the respondents were found to be belonging to lower middle and upper middle socio-economic status group in village community. Exposure of respondents to sources of information in general was noted to be of medium level. The majority of the respondents (72.67%) had medium level of scientific orientation.

Key words : Socio-economic, communication and psychological characteristics of the sorghum growers.

Sorghum occupies an important place in the food grain crops because; it is staple food for large population of India. The figures of area and production in the state shows that the area under kharif sorghum is reducing day by day from 27,51,000 ha in 1990-91 to 19,18,000 ha in 1999-2000. In Akola district of Vidharbha region the trend was found to be similar. In 1995-96 the area under sorghum in the district was 1,25,000 ha and in 1999-2000 it was 1,06,060 ha. This has necessitated ascertaining the socio-economic, communication and psychological characteristics of the sorghum growers to identify the reasons for reduction in area and the technological needs of farmers. With this aim the present study was undertaken.

MATERIALS AND METHODS

The present study was carried out in purposively selected Akola district of Maharashtra State. The statistical information about the area under kharif sorghum during 2001-2002 in various Panchayat Samiti's in Akola district were collected. The area under kharif sorghum crop in Barshitakli Panchayat Samiti was higher, that is, 15,800 ha during 2001-2002 hence it was selected for the study.

There were 120 villages where kharif sorghum was grown. Out of these villages 15 villages having higher area under kharif sorghum cultivation during 2001-2002 were purposively selected. The emphasis in the study was on assessing socio-economic, communication and psychological characteristics of the sorghum growers; hence the use of expiratory design of social research in the present investigation was made. The list of the sorghum growers whose area under kharif sorghum had been reduced during the last five years was again prepared from the records of Talathi. That list of 150 farmers was drawn with the help of Tippets random number table. Keeping in views the objectives of the study a structured interview schedule was developed for data collection. The data were collected in a face to face contact by contacting the selected farmers. The data collection work from 150 respondents was undertaken from 22nd February to 8th March, 2003.

RESULTS AND DISCUSSION

a) Socio-economic characteristics

Education

Considering the formal schooling the respondents were grouped in five categories and

the results obtained are given in Table 1. It could be noticed that 30 per cent of the respondents were educated up to high school level. A meager percentage of respondents (10%) were found to be illiterate. It could be made out that majority of the respondents (54%) were more than high school educated. The present findings therefore supports to be findings of Valekar (1997) that majority of the farmers were educated up to high school level.

Land holding

It is seen from Table 1 that more than one third (39.33%) of the respondents were medium land holders having land holding ranging from 10.01 to 25.0 acre. The sorghum farmers in majority (72.66%) belonged to medium category of land holding ranging from 5.01 to 25.0 acre. The present findings were similar to be findings of Valekar (1997) and Deole (1997) that majority of the farmers were medium land holders.

Area under sorghum crop

The distribution in Table 1 reveal that majority of the respondents (60.67%) had put the area of 1.01 to 2.0 areas under kharif sorghum crop. A meager percentage (9.33%) of the respondents had put up to 1 acre area under kharif sorghum crop. Thus majority of the sorghum growers (60.67%) had an area of 1.01 to 2.00 acres under kharif sorghum. The present findings, therefore, support to the findings of Anonymous (1997) that similar majority of the respondents had could the area up to one ha under sorghum.

Farming experience

The distribution of farmers according to their farming experience is given in Table 1. It is seen from Table 1 that more than half of the respondents (72.00%) had a farming experience between 11 to 15 years. The present findings therefore support to the findings of Valekar (1997) that similar of the respondents had a farming experience between 11 to 15 years.

Annual income

It is evident from Table 1 that one third of the respondents (33.33%) had annual income above Rs. 1,00,000. Comparatively a small percentage of the respondents had annual income

below Rs. 25,000 (16%) and annual income in between Rs. 75,001 to Rs. 1,00,000.

Social participation

It could be observed that (Table 1) nearly fifty per cent (49.33%) respondents low participation in social organization. Only 15.33 per cent of the respondents were observed in high social participation category. It may be inferred that majority of the respondents had low social participation indicating that they had a membership in social organization that to the village cooperative society. This may be because they have to borrow crop loan from Cooperative Bank through Village Cooperative. The present findings therefore support to the findings of Khade (1996), Kadam (1984) and Valekar (1997) that majority of the respondents had low social participation.

Socio-economic status

The data in Table 1 in respect of socio-economic status reveals that over one third of the respondents (34.66%) belonged to middle socio-economic status group. The percentage of respondents belonging to upper category of socio-economic status was very meager. The respondents in general had medium level of standing in the socio-economic characteristics.

b) Communication characteristics

Source of information

From the Table 2 it is showed that the respondents used to obtain information about kharif sorghum cultivation technology and alternative uses of stalk and grains of sorghum through contact with friends (67.33%), proprietor of Agron service centers (56.00%), progressive farmers (55.33%), participation in Shetkari Melawa (48.67%) and Shivarpheri (50.00%), watching of farm TV telecast (47.33%) and hearing farm radio broadcasts (66.67%) sometimes. However, majority of the respondents were found to be not making use of sarpanch, gramsevak, extension workers of panchayat samiti and magazine/farm literature and Krishi Dainandini.

The extension workers of panchayat samiti and single window should, therefore, try to make themselves available for contacts with the

Table 1. Distribution of respondents according to their socio-economic characteristics

S.No.	Variables and category	Respondents (n=150)	
		Number	Percentage
I	Education		
1	Illiterate	15	10.00
2	Primary school	27	18.00
3	Middle school	27	18.00
4	High school	45	30.00
5	College	36	24.00
II	Land holding (acre)		
1	Marginal	1	0.67
2	Small	24	16.00
3	Semi-medium	50	33.33
4	Medium	59	39.33
5	Large	16	10.67
III	Area under sorghum crop (acre)		
1	Up to 1 acre	14	9.33
2	1.01 to 2.0 acre	91	60.67
3	2.01 to 3.00 acre	18	12.00
4	Above 3.00 acre	27	18.00
IV	Farming experience (year)		
1	Up to 10	27	18.00
2	11 to 15	108	72.00
3	Above 15	15	10.00
V	Annual income (Rs.)		
1	Up to Rs. 25,000	24	16.00
2	Rs. 25,001 to Rs. 50,000	42	28.00
3	Rs. 50,0001 to Rs. 75,000	26	17.33
4	Rs. 75,001 to Rs. 1,00,000	8	5.33
5	Above Rs. 1,00,000	50	33.33
VI	Social participation		
1	Low	74	49.33
2	Medium	53	35.33
3	High	23	15.33
VII	Socio-economic status		
1	Lower	0	0.00
2	Lower middle	48	32.00
3	Middle	52	34.66
4	Upper middle	49	32.67
5	Upper	1	0.67

farmers for providing information about kharif sorghum cultivation and alternative uses of stalk and grains of sorghum.

The data regarding the extent of utilization of various sources of information depicted in Table 3 indicate that majority of the respondents (55.33%) had medium level of exposure to various sources for getting information about

kharif sorghum technology. Thus majority of the respondents were found to be using various sources of information about kharif sorghum technology only to medium extent.

By and large, the respondents were found to be not using various sources of information to all possible extent to acquire the information, about kharif sorghum technology. The present

Table 2. Distribution of respondents according to frequency of use of different sources of information

S.No.	Sources	Frequency of use (n=150)		
		Always	Sometimes	never
I	Personal sources			
1	Friends	47 (31.33)	101 (67.33)	2 (1.33)
2	Gram sevak	2 (2.66)	54 (36.00)	92 (61.34)
3	Sarpanch	6 (4.00)	66 (44.00)	78 (52.00)
4	Progressive farmers	60 (40.00)	83 (55.33)	7 (4.67)
5	Proprietor of agro service centers	60 (40.00)	84 (56.00)	6 (4.00)
6	Extension workers of single window system	6 (4.00)	46 (30.66)	98 (65.33)
7	Extension workers of Panchyat samiti	7 (4.67)	51 (34.00)	92 (61.33)
8	University scientists	5 (3.33)	35 (23.33)	110 (73.33)
II	Land holding (acre)			
1	Shetkari melawa	27 (18.00)	73 (48.67)	50 (33.33)
2	Agriculture exhibition	19 (12.67)	60 (40.00)	71 (47.33)
3	Shivarpheri	23 (15.33)	75 (50.00)	52 (34.67)
III	Media sources			
1	Radio	21 (14.00)	100 (66.67)	29 (19.33)
2	Television	34 (22.67)	71 (47.33)	45 (30.00)
3	News paper	27 (18.00)	55 (36.67)	68 (45.33)
4	Agril. Magazine/Farm Literature	13 (8.67)	44 (29.33)	93 (62.00)
5	Krishi dairy/Dainandini	7 (4.67)	30 (20.00)	113 (75.33)

findings therefore support to the findings of Jagdale and Nimabkar (1993), Khade (1996), Valekar (1997) and Gharule (1998) that majority of farmers were under medium level of use of sources of information for acquisition of scientific information about sorghum cultivation.

c) Psychological characteristics

Scientific orientation

The data depicted in Table 4 indicate the

majority of the respondents (72.67%) had medium level of scientific orientation. A meager percentage of respondents (6.00%) were found to be high in scientific orientation about kharif sorghum technology. In orientation of scientific thinking in the farmers is, therefore, essential. The present findings therefore support to the findings of Valekar (1997) that majority of farmers had medium level of scientific orientation.

Table 3. Distribution of respondents according to the level of use of sources of information

S.No.	Category	Respondents (n=150)	
		Number	Percentage
1	Low	40	26.67
2	Medium	83	55.33
3	High	27	18.00
4	Total	150	100.00

Table 4. Distribution of respondents according to the level of use of scientific orientation

S.No.	Category	Respondents (n=150)	
		Number	Percentage
1	Low	32	31.33
2	Medium	109	72.67
3	High	9	6.00
4	Total	150	100.00

From present investigation it is concluded that the area under sorghum in Vidharbha region decreasing due to following socio-economic, communication and psychological characteristics of the sorghum growers as a higher percentage of respondents (30.00%) were found to be educated upto high school. More than one third of the respondents (39.33%) belonged to medium land holding category of 10.01 to 25.00 acre. The majority of the respondents (60.67%) had put an area of 1.01 to 2.00 acre under kharif sorghum crop. The farming experience of majority of the respondents (72.00%) was found to be from 11 to 15 years. One third of the respondents (33.33%) of the respondents (72.00%) was found to be from 11 to 15 years. One third of the

respondents (33.33%) had their annual income above Rs. 1,00,000. Nearly fifty per cent (49.33%) of the respondents were found to be low in social participation. The majority of the respondents were found to be belonging to lower middle and upper middle socio-economic status group in village community. The respondents in majority were found to be contacting friends (66.63%). They were also found to be participating in Krishi melawa and shivar pheri and including use of television and radio programmes sometimes for obtaining information. Exposure of respondents to sources of information in general was noted to be of medium level. The majority of the respondents (72.67%) had medium level of scientific orientation followed by 21.33 per cent having low scientific orientation.

REFERENCES

- Anonymous 1997. constraints in cultivation of Rabi sorghum. Report submitted to Research Reviews. Subcommittee Extension Education, Dr. PDKV, Akola.
- Deole, S.G. 1997. A study on adoption of dryland technology for bajra in Beed district. Maharashtra State. M.Sc. Thesis (Unpub.), MAU, Parbhani.
- Gharule, S.B. 1998. A study on adoption of package of practices of kharif sorghum. M.Sc. Thesis (Unpub.), MAU, Parbhani.
- Jagdale, V.D. and Nimbalkar S.D. 1993. Role of socio-personal, economic and psychological characteristics of farmers on knowledge level about improved dryland technology. *Maharashtra J. Extn. Educ.* XII: 119-123.
- Kadam, L.K. 1984. Adoption of dryland technology in drought prone area. M.Sc. Thesis (Unpub.), MAU, Parbhani.
- Khade, H.A. 1996. A study on adoption of dry land technology of kharif sorghum. M.Sc. Thesis (Unpub.), MAU, Parbhani.
- Valekar, R.B. 1997. Adoption behavior of rabi sorghum growers. M.Sc. Thesis (Unpub.), Dr. PDKV, Akola.

SOIL CRITICAL SULPHUR AVAILABILITY INDEX FOR RAYA (*BRASSICA JUNCEA* L.) IN HILL SOILS OF NORTH-WEST HIMALAYAN REGION

RAKESH SHARMA¹ AND JAGAT RAM

Department of Soil Science H.P.K.V., Palampur-176062

¹Department of Soil Science and Water management

Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni Solan - 173 230 (H.P.)

ABSTRACT

A pot experiment was conducted to study sulphur responses and soil critical sulphur index in raya (*Brassica juncea*) using thirteen soils from wet temperate and humid sub-tropical zones of Kangra district of Himachal Pradesh. Sulphur application increase the dry matter yield, sulphur uptake and decreased the days taken to 50% flowering (advanced maturity of the crop). The magnitude of response was high in soils with critical sulphur availability index < 5.99 and low in case of sulphur availability index > 5.99.

Key words : Sulphur, *Brassica juncea*, critical availability index, hill soils.

Sulphur (S) is an important part of organic matter and its availability is dependent on transformation of organic matter. Organic form of sulphur is an important source in the soil from the point of plant availability; yet chemical extractant in vogue (0.15% CaCl_2 , monocalcium phosphate 500 mg P L⁻¹ etc.) do not directly take this source into account for assessing available S. In China, Liu et al. (1993) adopted sulphur availability index (SAI), to characterize sulphur availability in the soil and to predict response of crops to applied sulphur. They classified soil of China into low (SAI < 7) where response to applied S could be expected, medium (SAI 7 to 14) where response to applied S could be expected in case of crop having high S requirement (e.g. oil seeds) and high (SAI > 14) where no response to applied S could be expected. An attempt has been made in the study to explore the feasibility of adopting SAI to assess the S supplying capability of soils of important oil seeds growing areas of Kangra district in Himachal Pradesh.

MATERIALS AND METHODS

Thirteen bulk hill soils were collected for pot study from Kangra (Udorthents, Ustochrepts and Hapludalfs) district in Himachal Pradesh, where raya (*Brassica juncea*) based cropping systems were followed. These soils were

analysed for different physico-chemical properties following standard laboratory techniques. The samples selected for the study varied in texture from loamy sand to silty clay loam, pH from 5.3 to 7.1 (mean : 6.2), organic carbon from 7.0 to 13.8 g kg⁻¹ (mean : 10.3 g kg⁻¹), cation exchange capacity from 6.9 to 11.4 c mol (p+) kg⁻¹, available nitrogen from 240 to 368 kg N ha⁻¹, available phosphorus from 6.2 to 16.8 kg P₂O₅ ha⁻¹ and available potassium from 146 to 370 kg K₂O ha⁻¹. The available S content was extracted by 0.15% CaCl_2 (Williams and Steinbergs, 1959) and the S content in the extract was estimated by turbidimetric method of Chesnin and Yien (1950). It ranged from 8.5 to 11.3 mg kg⁻¹ soil in the soils under investigation.

A pot culture study was conducted during rabi 1995-96 using raya (var. Varuna) as test crop in enameled pots filled with eight kg soil per pot and randomly arranged in RBD with three replications. To each soil, S through gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$; 18.6% S) was applied at three levels viz., 0, 30 and 60 mg kg⁻¹. Uniform application of N, P and K were made @ 60, 40 and 40 kg ha⁻¹ using area, diammonium phosphate and muriate of potash, respectively. Seven plants of raya (*Brassica juncea* var. Varuna) in each pot were maintained and all recommended management practices were

adopted during crop growth. The soil moisture was maintained at 50% of the field capacity throughout by adding demineralized water as and when needed. The crop was grown up to 50% flowering stage (85 days). Bray's per cent yield was calculated by following the formula :

$$\text{Bray's per cent yield} = \frac{\text{Yield without sulphur}}{\text{Maximum yield with sulphur}} \times 100$$

RESULTS AND DISCUSSION

Critical limits for SAI were computed by correlating the per cent dry matter yield with SAI were computed by correlating the percent dry matter yield with SAI value by statistically method (Cate and Nielson, 1971). Soils were arranged in ascending order with regard to their SAI values along with corresponding Bray's percent dry matter yield. The R^2 values, calculated based on Cate and Nelwon (1971) statistical method, are presented in Table 1. It was found that significant relationship existed between SAI and Bray's per cent dry matter yield of raya. The critical SAI value for the raya crop under the present experimental conditions for the hill soils under study was found to be 5.99 at which, the maximum R^2 value obtained

was 0.67. The R^2 between Bray's per cent dry matter yield and available sulphur as extracted by 0.15% CaCl_2 was found to be 0.84 at 10.3 mg S kg^{-1} (Rakesh Sharma, 1996) which indicates the soil critical level and below which response of raya to applied S could be expected. As compared to the observation of Liu *et al.* (1993), present SAI rating proposed has low values, thereby indicating relatively high requirement of raya of sulphur. No literature is available on critical SAI values for Indian Soils.

There was significant response of raya to S. Application (Table 2). Sulphur application increased the dry matter yield, S uptake and decreased the days to 50% flowering (advanced maturity of the crop) in both the SAI categories the response, in respect of dry matter yield was 19.4 to 37.2 per cent in 10 soils where SAI values are <5.99 and 12.3 to 22.0 per cent in three soils, where the SAI values are >5.99. The S application helps in advancing the maturity of the crops as revealed from the Table 2. The advancement was more pronounced in soils having SAI values > 5.99 as compared with low SAI values. The results of the study emphasized the application of higher levels of sulphur for high S demanding crops like raya and other crucifers oil seeds

Table 1. Critical sulphur availability index (SAI) of soils for raya (*Brassica juncea*)

Location	Available S (mg kg^{-1})	Sulphur availability index	Per cent dry matter yield	R^2	Postulated critical level
Jawalamukhi	8.5	4.60	79.9	0.44	-
Aalampur	8.5	4.64	62.2	0.63*	4.89
Kangra	9.2	5.27	74.3	0.59*	5.10
Dheera	9.7	5.47	77.9	0.50	-
Khaira	9.3	5.48	72.0	0.46	-
Guler	9.8	5.58	71.0	0.52	-
Dadh	9.2	5.66	68.0	0.48	-
Palampur	8.5	5.67	62.1	0.52	-
Baijnath	9.5	5.73	86.8	0.45	-
Rainital	11.3	5.86	72.4	0.59*	5.71
Shahpur	10.2	6.08	69.0	0.67*	5.99**
Gaggal	11.3	6.45	78.4	0.51	
Malan	11.3	6.90	85.7	0.50	

* 5% level of significance.

** Sulphur availability index (5.99) which gives highest R^2 value was taken as the critical level.

Table 2. Response of raya to S application in relation to soil availability index

SAI* in soils	No. of soils	Average dry matter yield (g pot ⁻¹)			Sulphur uptake (mg pot ⁻¹)			Days to flowering		
		S levels (mg kg ⁻¹)			S level (mg kg ⁻¹)			S level (mg kg ⁻¹)		
		0	30	60	0	30	60	0	30	60
<5.99	10	27.4	32.7 (19.4)	37.6 (37.2)	49.9	91.2 (82.7)	133.2 (166.9)	76.8	74.0 (3.6)	71.3 (7.2)
<5.99	3	31.3	35.1 (12.3)	38.5 (22.0)	72.0	99.9 (38.7)	119.75 (66.2)	71.0	67.5 (4.9)	61.0 (14.1)

*SAI = sulphur availability index

Figures in parenthesis are per cent response over S₀.

where the SAI values are < 5.99. The response pattern was more clear and relatively higher in soils of wet temperate region as compared to humid sub-tropical area of Kangra district. Therefore, the result of the investigation clearly

indicates that the critical SAI formulated and fixed in the present study is able to predict field response of raya (*Brassica juncea*) to applied S in the soils of wet temperate and humid sub-tropical zone of Himachal Pradesh.

REFERENCES

- Cate, R.B. and Nelson, L.A. 1971. *International Soil Testing Service Technical Bulletin No. 1.*
- Chesnin, L., and Yien, C.H. 1950. *Proc. Soil Sci. Soc. of Am*, **15**, 149-151.
- Liu, C. Q., Cao Shuqing and Waijun. 1993. *Sulphur in Agriculture*, **17**, 3.
- Sharma Rakesh. 1996. *M.Sc. Thesis, H.P.K.V. Palampur (H.P.)*
- Williams, C.H. and Steinbergs, A. 1959. *Aus. J. Agric. Res.* **10**, 340-352.

MANAGEMENT OF N AND P IN WHEAT + CHICKPEA INTERCROPPING SYSTEM ON YIELD ATTRIBUTING CHARACTERS AND YIELD OF CHICKPEA UNDER RAINFED CONDITIONS

AJAY KUMAR AND R.K. SINGH

*Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Field experiments were conducted for the management of nitrogen and phosphorus in wheat + chickpea intercropping. Yield attributes viz., number of effective tillers m^{-1} , spike characters (length, number of spikelets and number of grains) increased markedly of chickpea in W + C intercropping in 2 : 3 row ratio than the sole wheat crop. Application of 30 kg N ha^{-1} to wheat crop significantly increased the number of branches $plant^{-1}$, number of grains pod^{-1} . Grain and straw yields of chickpea in both W+C intercropping and mixed cropping in both years and pooled data. Phosphorus application at 30 kg P_2O_5 ha^{-1} caused significant increase in yield attributes i.e., number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of grains pod^{-1} , grain and straw yield in the cropping system in both years and pooled data.

Key words : Nitrogen, phosphorus, wheat, chickpea, rainfed conditions.

Intercropping systems when cereals are grown with pulses, their fertilizer requirements differ than sole crop of cereal. The amount of nitrogen fertilizer could be reduced to a large extent by applying it to the responsive crop rows i.e., to wheat crop grown in an intercropping with pulse. The present study was, therefore, designed to study the performance of wheat sown in association with chickpea and fertilizer through urea was applied only to the wheat crop.

MATERIALS AND METHODS

The field experiment was carried out during the rabi seasons of 1999-2000 and 2000-2001 at the farm of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110012. The soil of the experimental field was of deep alluvial origin. A composite soil sample from 0-30 cm depth was collected from the experimental fields prior to experimentation to study the availability of major nutrient elements. The soil of the experimental field was sandy loam in texture, well drained, neutral to slightly alkaline in reaction (pH 7.3), poor in organic matter content, low in available nitrogen and

phosphorus but fairly adequate in available potassium.

The experiment was laid out consisting four cropping systems viz., wheat (W) sole, Chickpea (C) sole, W+C mixed cropping and W+C intercropping (2:3 row ratio in row replacement series) with four nitrogen levels (0, 30, 60 and 90 kg N ha^{-1}) along with two levels of P (0 and 30 kg P_2O_5 ha^{-1}) was conducted in randomized block design with three replications.

The variable doses of nitrogen in the form of urea were placed to wheat rows only. Whereas, phosphorus (30 kg P_2O_5 ha^{-1}) in the form of single superphosphate was placed to both the crops equally as per the treatments. The placement of fertilizer was done at 8-10 cm deep with the help of bullock drawn country plough before sowing. The sowing was done by pora method at 25 cm row spacing with the help of manually operated hand plough.

BHC dust at the rate of 20 kg ha^{-1} was uniformly spread and mixed with soil before sowing for protection against termites. One spray of metasystox (0.02%) with 800 lit. water soluble

ha⁻¹ was sprayed to protect the wheat crop from Brown mite (*Paltobie lactae*) at primordial stage and to protect the chickpea crop from Pod borer. Both the crops were harvested separately before threshing in the mixed cropping system.

RESULTS AND DISCUSSION

Yield attributing characters of chickpea

Number of branches plant⁻¹

Among the cropping systems, the number of branches plant⁻¹ in W+C intercropping was statistically significant over the mixed cropping and sole chickpea crop in both years (Table 1). The application of nitrogen at 30 kg ha⁻¹ to wheat crop grown in intercropping (2:3 row ratio) crop caused a significant increase in number of branches plant⁻¹ in chickpea in both years, whereas higher dose used decline in number of branches in both years. Application of phosphorus at 30 kg P₂O₅ ha⁻¹ significantly increased the number of branches plant⁻¹ over no phosphorus treatment in both years.

Number of pods plant⁻¹

Among cropping systems without nitrogen and phosphorus application, the higher number of pods plant⁻¹ were recorded in sole chickpea followed by W + C intercropping (2:3 row ratio) but the difference was at par when nitrogen was applied to wheat rows in W + C intercropping system, the number of pods of plant⁻¹ and intercropping were statistically higher as compared to sole and mixed cropping. Application of 30 kg N ha⁻¹ to wheat crop brought a significant increase in number of pods plant⁻¹ in chickpea in both years. Application of 30 kg P₂O₅ ha⁻¹ recorded significantly higher number of pods plant⁻¹ over no phosphorus application in first year only.

Number of grains pod⁻¹

Various cropping systems did not influence the number of grains pod⁻¹ of chickpea. Phosphorus application at 30 kg P₂O₅ ha⁻¹ was found significant in sole crop as well as in both the cropping systems over no phosphorus application. The percentage increase with 30 kg P₂O₅ ha⁻¹ over no phosphorus in sole chickpea W + C intercropping and W + C mixed cropping were 5.08, 5.83 and 4.96 in 1999-2000 and 5.83,

4.88 and 4.10, respectively.

Test weight (g)

Test weight of the chickpea was not affected by various cropping systems, nitrogen and phosphorus application in both years. However, application of 30 kg P₂O₅ recorded higher values of test weight over no phosphorus application in all the cropping systems.

Grain yield

Among the cropping systems with nitrogen application to wheat rows, grain yield of chickpea was recorded significantly higher in intercropping (2:3 row ratio) as compared to mixed cropping in both years and pooled data (Table 2). The percentage increase in W + C intercropping over W + C mixed cropping was 10.76, 9.24 and 9.98 in first year, second year and pooled data, respectively.

The grain yield of chickpea, when nitrogen was not applied in wheat rows in any of the cropping system, was statistically higher in sole stand compared to mix or intercropping in both years and pooled data. The percentage increase in sole and intercropped chickpea over mixed cropping were 44.54, 12.50 in 1999-2000 and 44.22, 12.22 in 2000-2001 and 44.36 and 12.33 in pooled data, respectively. Phosphorus application at 30 kg P₂O₅ ha⁻¹ recorded significant increase in grain yield in all cropping systems of chickpea in both years and also in pooled data. Contrast analysis P₀ vs. other was significant in both years and pooled data.

Straw yield

The application of N in W + C intercropping treatment recorded significantly higher straw yield as compared to mixed cropping. Without nitrogen application, sole stand of chickpea had highest straw yield as compared to other cropping systems in both years and pooled data. The difference between each systems was significant in both years and pooled data. The percentage increase in yield in intercropping and sole stand of chickpea over mixed cropping was 12.4 and 25.0 in first year, 6.24 and 33.3 in second year and 9.26 and 34.14 in pooled data, respectively.

Application of phosphorus at 30 kg P₂O₅ ha⁻¹

Table 1. Yield attributing characters of chickpea as affected by cropping systems and nitrogen and phosphorus management

1999-2000					
Number of branches					
Extra Treatment	W+C(Mix) N ₀ P ₀	W+C (2:3) N ₀ P ₀	Chickpea N ₀ P ₀	Chickpea N ₀ P ₃₀	
	5.20	5.50	5.70	6.40	
Cropping system	N ₀ P ₃₀	N ₃₀ P ₃₀	N ₆₀ P ₃₀	N ₉₀ P ₃₀	Mean
W+C(Mix)	5.97	6.73	6.20	6.10	6.25
W+C (2:3)	6.50	7.67	6.87	6.70	6.93
Mean	6.23	7.20	6.53		
	General	CS	N	CS×N	Constrast
SEm±	0.231	0.116	0.163	0.231	
C.D.	0.68	0.34	0.48	NS	NS
Number of pod plant⁻¹					
Extra Treatment	54.5	56.0	58.2	62.1	
W+C(Mix)	56.1	59.8	58.2	56.2	57.6
W+C (2:3)	57.7	62.1	62.4	61.8	61.0
Mean	56.9	61.0	60.3	59.0	
	General	CS	N	CS×N	Constrast
SEm±	1.4	0.7	1.0	1.4	
C.D.	4.0	2.0	2.8	NS	NS
Number of grains pod⁻¹					
Extra Treatment	1.15	1.17	1.12	1.18	
W+C(Mix)	1.21	1.26	1.24	1.20	1.23
W+C (2:3)	1.22	1.28	1.30	1.27	1.27
Mean	1.22	1.27	1.27	1.24	
	General	CS	N	CS×N	Constrast
SEm±	0.05	0.05			
C.D.	0.15	NS	NS	NS	NS
Grain yield plant⁻¹					
Extra Treatment	15.6	16.4	16.2	18.5	
W+C(Mix)	17.3	19.0	18.4	17.0	17.9
W+C (2:3)	18.0	20.4	20.6	20.0	19.7
Mean	17.6	19.7	19.5	18.5	
	General	CS	N	CS×N	Constrast
SEm±	0.6	0.3	0.4	0.6	
C.D.	1.7	0.8	1.2	NS	NS
Test weight					
Extra Treatment	249.9	250.4	246.6	252.6	
W+C(Mix)	251.5	253.7	255.2	249.9	252.6
W+C (2:3)	253.3	254.7	254.1	252.1	253.6
Mean	252.4	254.2	254.7	251.0	
	General	CS	N	CS×N	Constrast
SEm±	4.6	2.3	3.3		
C.D.	NS	NS	NS	NS	NS
2000-01					
Number of branches					
Extra Treatment	6.00	7.30	6.80	7.95	
W+C(Mix)	7.15	8.00	7.47	7.20	7.34
W+C (2:3)	8.40	9.20	8.90	8.67	8.74

Contd...

Table 1 contd...

Mean	7.45	8.60	8.18	7.93	
	General	CS	N	CS×N	Constrast
SEm±	0.349	0.174	0.247	0.349	
C.D.	1.02	0.51	0.72	NS	NS
Number of pod plant⁻¹					
Extra Treatment	55.3	56.8	60.1	63.4	
W+C(Mix)	56.7	60.2	58.7	53.6	57.3
W+C (2:3)	57.8	63.3	63.4	59.6	61.0
Mean	57.3	61.8	61.1	56.6	
	General	CS	N	CS×N	Constrast
SEm±	2.1	1.0	1.7	2.1	
C.D.	6.1	3.1	3.5	NS	NS
Number of grains pod⁻¹					
Extra Treatment	1.17	1.17	1.13	1.20	
W+C(Mix)	1.22	1.28	1.25	1.19	1.24
W+C (2:3)	1.23	1.29	1.31	1.28	1.17
Mean	1.23	1.28	1.28	1.24	
	General	CS	N	CS×N	Constrast
SEm±	0.04	0.02			
C.D.	0.12	NS	NS	NS	NS
Grain yield plant⁻¹					
Extra Treatment	15.7	16.3	16.8	18.4	
W+C(Mix)	17.4	19.1	19.2	16.7	18.1
W+C (2:3)	18.1	20.6	20.9	20.1	19.9
Mean	17.8	20.1	20.5	18.4	
	General	CS	N	CS×N	Constrast
SEm±	0.6	0.3	0.4	0.6	
C.D.	1.7	0.8	1.1	NS	S
Test weight					
Extra Treatment	251.0	255.8	247.7	252.9	
W+C(Mix)	254.7	258.7	256.5	252.3	255.6
W+C (2:3)	255.8	256.1	255.3	252.2	254.8
Mean	255.2	257.4	255.9	253.3	
	General	CS	N	CS×N	Constrast
SEm±	5.1	2.6	3.6		
C.D.	NS	NS	NS	NS	NS

increased the straw yield of chickpea as compared to no phosphorus in first year and pooled data. Contrast analysis P_0 vs. others was also significant in both the years and also in pooled data.

Higher yield of grain and straw of sole chickpea was more due to more number of rows per unit area (per plot) in sole stand as compared to inter and mixed cropping i.e. in 2:3 row ratio there was 4 rows of wheat and six rows of chickpea whereas in sole chickpea plot there was 10 row plot. Nitrogen application caused a

significant increase in grain and straw yield with 30 kg N ha⁻¹ and thereafter addition of nitrogen caused reduction because pulse crop require less N only to start the growth and thereafter pulse crop met its demand by fixing atmospheric nitrogen through nodules. Rawsthorne et al. (1985) reported that small starter dose of nitrogen (15 to 25 kg ha⁻¹) increased yield of chickpea on sandy loam soils. Singh and Khangarot (1987) also found that with 20 kg N ha⁻¹ enhanced grain and straw yields.

Phosphorus application 30 kg P₂O₅ ha⁻¹

Table 2. Grain and Straw yield (q ha⁻¹) of chickpea as affected by cropping systems and nitrogen and phosphorus management

Grain 1999-2000					
Extra Treatment	W+C(Mix) N ₀ P ₀	W+C (2:3) N ₀ P ₀	Chickpea N ₀ P ₀	Chickpea N ₀ P ₃₀	
	9.80	11.20	17.67	22.33	
Cropping system	N ₀ P ₃₀	N ₃₀ P ₃₀	N ₆₀ P ₃₀	N ₉₀ P ₃₀	Mean
W+C(Mix)	14.20	17.60	15.90	14.00	15.43
W+C (2:3)	15.70	18.93	17.50	17.03	17.29
Mean	14.95	18.27	16.70	15.52	
	General	CS	N	CS×N	Constrast
SEm±	0.92	0.46	0.55	0.92	
C.D.	2.7	1.35	1.91	NS	N
2000-2001					
Extra Treatment	11.10	12.63	19.90	23.20	
W+C(Mix)	14.23	17.00	16.10	13.57	15.23
W+C (2:3)	16.10	18.90	17.70	14.40	16.78
Mean	15.17	17.95	16.90	13.98	
	General	CS	N	CS×N	Constrast
SEm±	0.88	0.44	0.62	0.88	
C.D.	2.57	1.28	1.82	NS	S
Pooled					
Extra Treatment	10.45	11.92	18.78	22.77	
W+C(Mix)	14.22	17.30	16.00	13.78	15.33
W+C (2:3)	15.90	18.92	17.60	15.72	17.03
Mean	15.06	18.11	16.80	14.75	
	General	CS	N	CS×N	Constrast
SEm±	0.68	0.34	0.48	0.68	
C.D.	2.00	1.00	1.41	NS	S
Straw					
1999-2000					
Extra Treatment	14.97	17.09	23.03	27.04	
W+C(Mix)	19.07	22.52	21.54	20.50	20.91
W+C (2:3)	20.92	23.70	23.60	24.64	23.21
Mean	19.99	23.11	22.57	22.57	
	General	CS	N	CS×N	Constrast
SEm±	1.26	0.63	0.89	1.26	
C.D.	3.68	1.84	2.60	NS	S
2000-2001					
Extra Treatment	16.98	18.11	25.47	27.98	
W+C(Mix)	19.47	22.25	21.80	19.57	20.77
W+C (2:3)	21.35	23.65	23.91	20.32	22.31
Mean	20.41	22.95	22.85	19.95	
	General	CS	N	CS×N	Constrast
SEm±	1.24	0.62	0.88	1.24	

Contd...

Table 2 contd...

C.D.	3.63	1.82	2.58	NS	S
Pooled					
Extra Treatment	15.97	17.60	24.25	27.51	
W+C(Mix)	19.27	22.39	21.67	20.04	20.84
W+C (2:3)	21.13	23.67	23.75	22.48	22.76
Mean	20.20	23.03	22.71	21.26	
	General	CS	N	CS×N	Constrast
SEm±	0.95	0.47	0.67	0.95	
C.D.	2.77	1.39	1.96	NS	S

recorded significant increase in grain yield of chickpea. These results showed that even in moisture stress situations pulse requires phosphorus. This is far better root development and other biosynthetic activities, increased cell division and more development of meristematic tissue, metabolic processes of photosynthesis resulting in increased carbohydrate

accumulation and its mobilization to reproductive parts which resulted in increased yield. Parihar and Tripathi (1989) reported that grain yield of chickpea was statistically influenced by application of P up to 50 kg P₂O₅ ha⁻¹. Tomar and Raghu (1994) reported that 60 kg P₂O₅ ha⁻¹ caused an increase in harvest index under rainfed conditions.

REFERENCES

- Parihar, S.S. and Tripathi, R.S. 1989. Dry matter, nodulation and nutrient uptake in chickpea (*Cicer arietinum* L.) as influenced by irrigation and phosphorus. *Expl. Agric.*, 25(3) : 349-355.
- Rawsthorne, S., Hadley, P., Summerfield, R.J. and Roberts, E.H. 1985. Effects of supplemental nitrate and thermal regime on the nitrogen nutrition of chickpea (*Cicer arietinum* L.). *Pl. Soil*, 95 : 351-359.
- Singh, G. and Khangarot 1987. Effect of nitrogen and agrochemicals on chickpea. *Indian J. Agron.*, 32(1) : 4-6.
- Singh, R.K., De, R., Gangasaran and Turkhede, B.B. 1981. Dryland wheat yield as affected by soil application of fertilizer nitrogen and farmyard manure and foliar application of kaolin and CCC. *Indian J. Agric. Sci.*, 51(3) : 167-172.
- Tomar, R.K.S. and Raghu, J.S. 1994. Response of chickpea to phosphorus and rhizobium inoculation under rainfed conditions. *Indian J. Pulses Res.*, 7(1) : 38-40.

INFLUENCE OF IRRIGATION LEVELS AND DICLOFOP-METHYL ON WEED GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

RAJBIR SINGH*

Department of Agronomy
CCS Haryana Agricultural University, Hisar-125004

ABSTRACT

A field experiment was conducted to find out the effect of irrigation levels and post emergence application of diclofop-methyl on weed growth and yield of wheat. Experimental results revealed that there was significant increase in dry matter of grassy and broad leaf weeds with the increase in irrigation levels from one to six. Yield of wheat was significantly more with six irrigations at critical stages compared to one and three irrigations. Post emergence application of diclofop-methyl at 1.0 kg/ha provided good control of grassy weeds and produced grain yield at par with isoproturon at 1.0 kg/ha. However, diclofop-methyl applied at different doses failed to control the broad leaf weeds significantly indicating its ineffectiveness against broad leaf weeds.

Key words : Irrigation, weed control, diclofop-methyl, wheat.

Productivity of wheat has improved due to judicious application of irrigation and weed control management. The crop faces more problems of weeds under irrigated condition depending upon the amount of irrigation water supplied to the crop. Considering different methods of weed control, herbicides show promising results under irrigated condition. Of the different herbicides, Isoproturon is in use since 1982 in wheat. However, there are frequent reports of inadequate control of weeds due to development of resistance against isoproturon in Haryana and Punjab (Malik and Singh, 1993; Walia *et al.*, 1997). Keeping these aspects in view, the present investigation was carried out to evaluate alternate herbicide under varying irrigation levels for control of complex weed flora in wheat.

MATERIALS AND METHODS

The field experiment was conducted at agronomy research farm, Hisar during winter 1994-95 and 1995-96. Treatments consisting of 3 irrigation frequencies (1, 3 and 6) in main plot and six levels of weed control (diclofop-methyl@0.75 kg/ha; diclofop-methyl@1.0 kg/ha;

diclofop-methyl@1.25 kg/ha; isoproturon 1.0 kg/ha, weedy check and weed free) in subplots were replicated thrice in split plot design. Wheat 'WH283' was drilled on 10 December in 1994-95 and on 20 November in 1995-96 and was harvested on 30 April and 19 April in the respective years. The whole quantity of phosphorus and one third of nitrogen were applied at the time of sowing, while remaining nitrogen was top-dressed in 2 split at CRI and boot stage during both years. The irrigation applied at 21 day after sowing; at 21, 65 and 105 days; at 21, 45, 65, 85, 105 and 125 days under 1, 3 and 6 frequencies of irrigation. The herbicides with respective doses were sprayed at 35 days after sowing with a manually operated Knapsack sprayer with spray volume equivalent to 500 litres/ha. The water holding capacity, field capacity and permanent wilting point of the experiment field were 40, 17 and 6 percent, respectively. The moisture content in the soil at the time of sowing was 15.4 and 16.7 percent during 1995 and 96, respectively.

RESULTS AND DISCUSSION

Weed population

Averaged over year, the infestation was 29.8, 20.6, 9.3, 8.9, 4.4., 7.4, 10.5, 9.1 percent in

*Present address : Central Institute of Post Harvest Engineering and Technology, Abohar-152 116.

respect of *Phalaris minor* Retz., *Avena Ludoviciana* L., *Chenopodium album* L., *Melilotus indica* L., *Convolvulus arvensis* L., *Annagallis arvensis* L., *Vicia sativa* L. and *Rumex maritimus* L., respectively. Maximum weed frequency was noted during 10-35 days after sowing. Thereafter, the weed intensity remained constant upto 120 days. The population of wild canary grass (*Phalaris minor* Retz.), wild oat (*Avena Ludoviciana* L.) and broad leaf weeds did not vary significantly due to irrigation treatments (Table 1). This was due to common irrigation applied at CRI stage in all the three irrigation treatments. Similar results were obtained earlier by Hooda and Agarwal (1987).

The population of wild canary grass was significantly lower in all the herbicide treatments as compared to weedy check during both the seasons (Table 1). Increase in dose of diclofop-methyl from 0.75 to 1.25 kg/ha resulted into decrease in wild canary grass populations. However, differences were significant between 0.75 to 1.25 kg/ha only. Among different herbicide treatment, application of isoproturon at 1.0 kg/ha significantly reduced the population of wild canary grass during both years. Similarly, application of diclofop-methyl and isoproturon significantly reduced the population of wild oat as compared to weedy check. With the increase in diclofop-methyl rates from 0.75 to 1.25 kg/ha, the population wild oat decreased. Diclofop-methyl at 1.25 kg/ha controlled wild oat to the tune of 94 and 98 percent, respectively during 1994-95 and 1995-96 over weedy check. However, the reduction in population of wild oat was significant with diclofop-methyl applied at 1.25 kg/ha as compared to 0.75 kg/ha and isoproturon at 1.0 kg/ha during both the years. Isoproturon at 1.0 kg/ha gave 57 and 60 percent control of wild oat over weedy check during both years. Application of isoproturon 54 per cent over weedy check during 1994-95 and 1995-96. Application of different levels of diclofop-methyl did not influence the population of broad leaf weeds during both the years.

Weed biomass

Weed biomass observed at 120 days was significantly influenced due to different irrigation frequency during both the years. Averaged over

year, highest weed biomass was observed under six irrigation, which was 37.8 and 18.3 per cent higher as compared with one and three irrigation, respectively. The higher level of irrigation frequencies favored better growth of weeds that ultimately resulted in increased dry matter. Banga *et al.* (1993) also reported increased dry matter of weeds in wheat field with increase in the levels of irrigation.

Application of diclofop-methyl at each level significantly lowered the biomass of grassy weeds compared to weedy check during both the years (Table 1). The use of diclofop-methyl@ 1.25 kg/ha was found significantly superior to 1.0 kg/ha dose in reducing grassy weed biomass during both the years. Application of isoproturon @ 1.0 kg/ha lowered the biomass of grassy weed significantly compared to weedy check but at par with diclofop-methyl@1.0kg/ha. The reduction in dry matter of broad leaf weeds was significantly reduced with Isoproturon @ 1.0 kg/ha compared to diclofop methyl and weedy check. However, the dry weight of broad leaf weeds was not influenced by the application of diclofop-methyl at various doses indicating its ineffectiveness against broad leaf weeds. These results corroborate the earlier findings of Qureshi and Vander Born, (1979) and Balyan *et al.* (1987).

Growth of crop

The increase in number of irrigation produced significantly taller plants and more dry weight of wheat (Table 2). However, the effect was more on dry weight as compared to plant height. Increase in levels of irrigation has resulted into significant increase in dry weight of crop. At harvest, dry matter of wheat was significantly higher with six irrigation, which was 41.5 and 16.5 per cent higher with one and three irrigation, respectively averaged over years. These effects might have come through improved leaf area resulting in higher photosynthetic rate and more dry matter accumulation. These findings are in conformity with Hooda and Agarwal (1987).

Application of herbicides did not influence the plant height during both years. The dry weight of wheat was significantly lower in

Table 1. Population and dry weight of weeds at 120 DAS as influenced by irrigation and weed control treatments

Treatment	Weed population (No./m ²)						Weed dry weight (g/m ²)					
	Wild canary grass		Wild oat		Broad leaves		Grassy weeds		Broad leaf weeds			
	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96		
Irrigation frequency												
1	3.1(11.8)	3.1(11.3)	3.1(11.2)	3.3(14.6)	5.7(36.4)	5.6(38.4)	6.15(36.9)	6.74(44.5)	5.93(34.2)	6.15(36.8)		
3	3.6(15.1)	3.8(17.4)	3.5(16.0)	3.6(17.2)	5.9(38.9)	6.2(43.9)	6.72(44.2)	7.31(52.4)	6.28(38.5)	6.58(36.8)		
6	3.9(18.1)	4.6(23.5)	3.8(17.6)	4.0(20.9)	6.5(47.4)	6.9(54.2)	7.35(53.1)	7.79(59.8)	6.81(45.4)	7.23(42.4)		
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	0.35	0.32	0.29	0.31(51.7)		
Weed control												
Diclofop-methyl 0.75 kg/ha	4.5(19.3)	5.0(24.3)	4.0(16.1)	4.7(19.9)	7.0(55.8)	7.9(61.4)	6.95(47.3)	7.31(52.5)	7.26(51.7)	7.64(57.4)		
Diclofop-methyl 1.0 kg/ha	3.8(13.6)	4.5(19.2)	2.4(4.5)	2.1(3.6)	7.3(53.0)	7.6(55.6)	5.82(32.9)	6.48(41.0)	7.12(49.8)	7.53(55.7)		
Diclofop-methyl 11.25 kg/ha	3.3(10.0)	3.7(12.6)	1.8(2.6)	1.4(1.2)	7.8(59.5)	8.3(67.8)	4.81(22.3)	5.52(29.5)	7.42(54.1)	7.78(59.6)		
Isporo-turon 1.0 kg/ha	2.1(3.8)	2.0(3.2)	4.4(18.2)	4.9(23.2)	5.4(28.6)	5.3(27.3)	5.52(29.5)	6.19(37.3)	5.61(30.5)	5.81(32.8)		
Weedy check	6.6(41.8)	6.8(45.2)	6.6(42.3)	7.7(58.2)	7.6(57.9)	7.8(59.6)	11.7(136.7)	12.26(149.4)	7.01(48.2)	7.57(56.3)		
Weed free	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)		
C.D. (P=0.05)	1.1	0.9	1.0	0.8	1.4	1.6	0.51	0.48	0.44	0.50		

Values in parenthesis are original which were transformed by ($\sqrt{x+1}$).

Table 2. Growth, yield attributes and yield of wheat as affected by irrigation and weed control levels

Treatment	Plant height (cm)		Dry weight (g/m)		Spike/m row length		No. of grains per ear		Grain yield (kg/ha)	
	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96	1994-95	1995-96
Irrigation frequency										
1	92.6	93.8	188.9	197.2	71.9	74.8	49.8	51.4	3179	3516
3	97.2	98.3	266.1	284.9	82.2	86.3	51.7	52.2	4112	4287
6	101.8	103.6	323.6	336.4	91.0	95.5	53.5	53.9	4739	4973
C.D. (P=0.05)	3.5	4.1	15.2	10.4	4.7	6.3	1.5	0.6	311	378
Weed control										
Diclofop-methyl 0.75 kg/ha	96.4	99.7	252.5	266.5	79.3	83.2	50.9	51.8	3866	4142
Diclofop-methyl 1.0 kg/ha	96.1	99.4	266.8	280.1	83.1	86.4	52.4	52.6	4106	4389
Diclofop-methyl 11.25 kg/ha	95.4	99.2	257.6	274.5	81.6	87.1	51.3	53.0	4039	4284
Isporo-turon 1.0 kg/ha	97.1	100.0	278.1	289.7	86.4	90.4	52.7	53.9	4293	4547
Weedy check	95.7	99.9	210.9	22.9	69.7	71.3	49.3	49.8	3204	3357
Weed free	98.5	100.2	295.8	303.6	90.2	96.0	53.6	53.9	4540	4807
C.D. (P=0.05)	NS	NS	16.1	14.7	3.7	5.2	2.7	2.3	251	267

Values in parenthesis are original which were transformed by ($\sqrt{X+1}$).

weedy check than herbicide treatments. The highest dry weight of crop was obtained with weed free plots followed by Isoproturon at 1.0 kg/ha and diclofop-methyl at 1.0 kg/ha during both the years (Table 2). Among diclofop-methyl doses, highest crop dry weight was recorded with 1.0 kg/ha, which was at par with 0.75 and 1.25 kg/ha during both years. Diclofop-methyl at 1.25 kg/ha reduced the crop dry weight during initial stages, which was narrowed down at later stages indicating thereby a phenomenal recovery by crop from initial injury at high dose of diclofop-methyl. Recovery from initial injurious effects of higher dose(s) of diclofop-methyl on dry matter accumulation by wheat at later stages was also reported by Tag-El-Din *et al.* (1989).

Yield attributes and yield

Irrigation frequency of six to wheat crop produced significantly higher spikes per m row length and grains per spike compared to one and three irrigation frequency during both the years (Table 2). Optimum irrigation schedule (six irrigation at critical stages of wheat) recorded about 21 and 9 percent higher number of effective spike per meter row length than one and three irrigation, respectively, averaged over year. The more number of grains per ear with six irrigation might be ascribed to optimum moisture supply to wheat crop during various growth and development stages. Further, timely moisture supply through higher irrigation frequency might have also enhanced the nutrient intake by plant as reflected in better development of yield attributes. More spike per m row length and grains per spike at high moisture level was also recorded by Choubey *et al.* (1998). Irrigation levels increased the grain yield of wheat significantly during both the years. Increase in grain yield with 6 irrigations was to the tune to 33 and 30 percent over one and 13 and 15 percent over three irrigation in 1994-95 and 1995-96 respectively (Table 2). Significant increase in grain yield of wheat due to increasing level of irrigation was attributed to increased dry matter and improved values of different yield attributes. Higher yield at optimum irrigation level (6 irrigation) as compared to sub optimal irrigation level has also been reported by Das

and Yaduraju (1999).

The values of various yield attributes were recorded to be minimum with weedy check. Whereas, effective spikes/m row length and number of grains per ear were found highest with weed free treatment. This might be attributed to complete elimination of weed competition resulting into accumulation of more amount of photosynthates. The post-emergence application of herbicides significantly increased the yield attributing characters over weedy check during the years. Application of diclofop-methyl@1.0 kg/ha was found at par with Isoproturon@1.0 kg/ha in influencing these attributes during both years. However, the application of diclofop-methyl at 0.75 and 1.25 kg/ha produced significantly lower number of effective spikes than isoproturon at 1.0 kg/ha. The reduction in number of spikes might, therefore, be on account of indirect effect through inadequate control of grassy and broad leaf weeds by diclofop-methyl at 0.75 kg/ha and phytotoxic effect at 1.25 kg/ha on wheat.

Grain yield was highest in weed free treatment and minimum in weedy check. The magnitude of yield reduction was 41 and 43 percent in 1994-95 and 1995-96, respectively. Post emergence application of isoproturon was fairly close to weed free treatment in terms of wheat yield. Application of diclofop-methyl at 1.0 kg/ha was statistically at par with isoproturon at 1.0 kg/ha with respect to grain yield. An increase of 22.1, 29.4 and 26.8 per cent in wheat yield with the use of diclofop-methyl at 0.75, 1.0 and 1.25 kg/ha respectively, compared with the weedy check was noticed in pooled analysis. Application of diclofop at 1.25 kg/ha, though, controlled the weeds effectively but yielded relatively less probably due to its phytotoxic effect on wheat crop especially at early stage. Further, relatively lower yields under diclofop-methyl might be ascribed to its poor effect in controlling the broad leaf weeds (Malik *et al.* 1989). Higher yield of wheat under post emergence application of herbicides was due to reduced crop weed competition, thereby providing more congenial environment to wheat crop. Bhatia *et al.* (1981) has also reported increase in yield due to application of herbicide.

REFERENCES

- Balyan, R.S., Malik, R.K., Panwar, R.S. and Bhan V.M. 1987. Evaluation of herbicides for weed control in wheat. *Haryana Agric. Univ. J. Res.*, 17 (2) : 170-175.
- Banga, R.S., Singh, B.R. and Dhindwal, A.S. 1993. Effect of irrigation and herbicides on weed control in wheat. In : *Proc. Int. Symp. Indian Soc. of Weed Sci.*, Hisar, November 18-20 III : 258-59.
- Bhata, A.K., Das, N.L., Solanki, S.S. and Tiwari J.P. 1981. Chemical control of P. minor an irrigated wheat. *Indian J. of Weed Sci.*, 13 : 95-102.
- Choubey, N.K., Tripathi, R.S. and Ghosh, B.S. 1998. Influence of irrigation scheduling and weed control methods on weed growth and yield of wheat. *Indian Journal of Weed Science*, 30 : 128-131.
- Das, T.K. and Yaduraju, N.T. 1999. Role of fertilizer on crop weed competition in wheat as affected by irrigation. *Fertilizer News*, 44 (3) : 35-30.
- Hooda, I.S. and Agarwal, S.K. 1987. Studies on irrigation, weed control and fertility levels on growth and yield of wheat. *Indian Journal of Agronomy*, 32 : 261-64.
- Malk, R.K., Malik, R.S., Bhan, V.N. and Panwar, R.S. 1989. Influence of time of application of urea herbicides and diclofop-methyl in wheat. *Indian Journal of Agronomy*, 32 : 312-315.
- Malik, R.K. and S. Singh, 1993. Evolving strategies for herbicide use in wheat : Resistance and integrated weed management. In : *Proc. International Symposium on Integrated Weed Management for Sustainable Agriculture*, CCS Haryana Agricultural University, Hisar, India, 18-20, November, 1993.
- Qureshi, F.A. and Vanden Born. W.H. 1979. Split application and tank mixture combination of diclofop-methyl and MCPA for weed control in barley. *Can J. Plant. Sci.*, 59 : 87-92.
- Tag-El-Din, A.M.O. Ghandorah. Bait, Al-Mal, M. and Mostafa, S. 1989. Evaluation of some herbicides for weed control in wheat. *Journal of Agricultural Sciences, King Saud Univ.*, 2 : 105-137.
- Walia, U.S., L.S. Brar and B.K. Dhaliwal, 1997. Resistance to Isporo-turon in Phalaris minor Retz. in Punjab. *Plant Protection Quarterly*, 12 (3) : 138-140.

EVALUATION OF INTERCROPPING PATTERNS OF SOYBEAN (GLYCINE MAX)

VED PRAKASH, A.K. PANDEY AND A.K. SRIVASTVA

*Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora-263 601 (Uttanchal)*

ABSTRACT

The average total production in terms of pigeonpea equivalent yield, gross return and net returns enhanced by 17.0-45.4, 15.9 - 45.4 and 18.4 - 77.5 per cent, respectively due to different intercropping pattern over sole crop of pigeonpea planted in paired rows (30/90 cm). Pooled yield data showed that all the studied intercropping patterns caused significant reduction in grain yield of pigeonpea and soybean compared to their sole crop. Paired rows of pigeonpea + 2 rows of soybean recorded the highest pigeonpea equivalent yield (25.11 q/ha), land-equivalent ratio (1.42), maximum gross return (Rs. 45, 198/ha), net returns (Rs. 25,443/ha) and benefit cost ratio (2.28). The next best intercropping combination was pigeonpea + soybean in 1:1 row proportion in terms of pigeonpea equivalent yield (23.40 q/ha), gross returns (Rs. 42,120/ha), net returns (Rs. 22,365/ha), LER (1.30) and benefit : cost ratio (2.13).

Key words : Intercropping, pigeonpea, soybean, equivalent yield, gross returns, net returns.

There is ample scope to utilize the wider inter-row space in pigeonpea. Intercropping is one of the ways to increase oilseed and pulse production as intercropping is more advantageous than sole cropping of either oilseed or pulses (Prasad and Srivastava, 1991). Short duration varieties of pigeonpea perform well up to mid hills (1500 m amsl) of Uttanchal and area under soybean has increased rapidly owing to better yield potential and market price. Research information on intercropping of soybean and pigeonpea is meagre in Uttanchal. Hence, this study was undertaken to find out the most productive and remunerative intercropping pattern of soybean in pigeonpea.

MATERIALS AND METHODS

A field experiment was conducted during 1997 and 1998 to evaluate the different intercropping pattern of soybean and pigeonpea under rainfed conditions at Experimental Farm, Hawalbagh of Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora. Seven treatments [T₁, sole pigeonpea (60 cm); T₂, sole pigeonpea paired rows (30/90 cm); T₃, sole soybean; T₄, pigeonpea + soybean in 1:1 row proportion; T₅, pigeonpea paired rows (30/90 cm) + 1 row of soybean; T₆, pigeonpea paired rows (30/90 cm)

+ 2 rows of soybean; T₇; Soybean and pigeonpea planting in 4 : 2 row proportion], replicated thrice were evaluated in randomized block design. In alternate row planting method pigeonpea and soybean (1:1), 1 row of soybean was sown in between 2 rows of pigeonpea (60 cm apart). In paired rows planting of pigeonpea, spacing between rows and between paired rows was kept 30 and 90 cm apart, respectively, and 1 row or 2 row of soybean were sown in between 2 paired rows of pigeonpea. Pigeonpea cv. UPAS 120 and soybean cv. VL Soya 2 were sown in first fortnight of June. A basal dose of N, P₂O₅ and K₂O @ 25, 50 and 20 kg/ha to sole pigeonpea and @ 20, 80 and 40 kg/ha to sole soybean and its intercropping systems was applied. Economics was worked out on the basis of existing market prices. The land equivalent ratio (LER) was computed as suggested by Willey (1979). Pigeonpea equivalent yield was calculated by converting the seed yield of soybean into pigeonpea seed equivalent yield on the basis of existing sale price in the market.

RESULTS AND DISCUSSION

Grain yield

Pigeonpea sown in rows either 60 cm apart or paired planting (30/90 cm) yielded at par.

Pooled yield data showed that sole pigeonpea planting recorded highest yield. Pigeonpea yields in all the intercropping systems were reduced significantly compared to sole pigeonpea yield. Soybean and pigeonpea intercropped in 4 : 2 row proportion registered significantly lower pigeonpea yield (6.98 q/ha) followed by alternate planting of soybean and pigeonpea in 1 : 1 row proportion (7.13 q/ha). Halvankar *et al.* (2000) also reported low yield of pigeonpea in alternate planting of soybean and pigeonpea.

In pooled data, the highest soybean yield was obtained in sole cropping. Soybean as an intercrop with pigeonpea reduced the soybean yield significantly, which might be due to reduction in population and competition effects (Table 1). The findings corroborated the results of Tomar *et al.* (1987), Holkar *et al.* (1991) and Joshi *et al.* (1997). Soybean yield obtained under paired rows of pigeonpea + 2 rows of soybean was significantly higher than paired rows of pigeonpea + 1 row of soybean which might be due to higher plant population of soybean in former than later intercropping combination.

Pigeonpea equivalent yield

All the intercropping treatments proved significantly superior in terms of pigeonpea equivalent yield than sole pigeonpea and soybean. This is an agreement with the findings of Halvankar *et al.* (2000). Pigeonpea paired rows + 2 rows of soybean intercropping combination recorded highest pigeonpea equivalent yield (25.1 q/ha) which however was at par with pigeonpea + soybean in 1:1 row proportion (23.4 q/ha) and pigeonpea paired rows + soybean in 2:1 row proportion (22.43 q/ha) and significantly higher than soybean + pigeonpea in 4 : 2 row proportion (20.02 q/ha), sole crop of pigeonpea planted at 60 and 30/90 cm (17.11 and 17.27 q/ha) and soybean (18.35 q/ha). The total production in terms of pigeonpea equivalent yield enhanced by 17.0 - 45.4 per cent over sole pigeonpea paired rows (17.27 q/ha) due to different intercropping patterns.

Land equivalent ratio (LER)

All the intercropping systems proved more

efficient in utilizing the land resources and showed higher LER values 1.12 - 1.42 than sole cropping of either soybean or pigeonpea (Table 1). Prasad and Srivastava (1991) also recorded higher LER values in intercropping treatments. Paired planting of pigeonpea + 2 rows of soybean recorded the highest LER value (1.42).

Economics

All the intercropping treatments except planting of soybean and pigeonpea in 4 : 1 row proportion gave significantly higher gross returns than sole cropping of either pigeonpea or soybean (Table 2). Based on the pooled data, paired planting of pigeonpea (30/90 cm) + 2 rows of soybean recorded highest gross returns (Rs. 45,198/ha) followed by planting of pigeonpea and soybean in alternate rows (Rs. 42,120/ha). The mean gross return enhanced by 15.9 - 45.4 per cent due to different intercropping patterns over sole pigeonpea paired planting (Rs. 31,086/ha).

All the intercropping treatments except planting of soybean and pigeonpea in 4:1 row proportion produced significantly higher net returns than sole crops, either pigeonpea or soybean. Based on the average data of 2 years, paired planting of pigeonpea (30/90 cm) + 2 rows of soybean recorded maximum net return (Rs. 25,443/ha) followed by planting of pigeonpea and soybean in 1:1 row ratio (Rs. 22,365/ha) and paired planting of pigeonpea (20/90 cm) + 1 row of soybean (Rs. 21,679/ha). The net returns increased by 8.4 to 77.5 per cent due to different intercropping patterns over sole pigeonpea paired rows (Rs. 14,331/ha). These results corroborate the findings of Dubey *et al.* (1991).

Paired planting of pigeonpea (30/90 cm) + 2 rows of soybean exhibited the highest benefit : cost ratio (2.25) followed by paired rows of pigeonpea (30/90 cm) + 1 row of soybean (2:15).

Thus, intercropping of soybean in pigeonpea is more remunerative. Paired rows of pigeonpea (30/90 cm) + 2 rows of soybean should be followed to get higher monetary returns than sole cropping of either pigeonpea or soybean under rainfed conditions in North-Western Himalayas.

Table 1. Pigeonpea, soybean and pigeonpea equivalent yield as influenced by intercropping patterns of planting

Treatment	Grain yield (q/ha)						Pigeonpea equivalent LER			
	1997			1998			Mean		Yield (q/ha)	
	P.P.	S.B.	P.P.	S.B.	P.P.	S.B.	P.P.	S.B.	1997	1998
Sole pigeonpea (60 cm)	17.68	-	16.53	-	17.11	-	17.11	-	17.68	16.53
Sole pigeonpea paired rows (30/90 cm)	17.50	-	17.04	-	17.27	-	17.27	-	17.50	17.04
Sle soybean (45 cm)	-	30.00	-	25.04	-	27.52	27.52	20.00	16.69	18.35
Pigeonpea + soybean (1:1)	7.59	26.98	6.67	21.89	7.13	24.41	24.41	25.54	21.26	23.40
Pigeonpea paired rows+soybean (2:1)	15.32	12.32	13.06	12.50	14.19	12.41	12.41	23.46	21.39	22.43
Pigeonpea paired rows + soybean (2:2)	12.26	20.55	12.78	17.22	12.52	18.89	18.89	25.96	24.26	25.11
Soybean + Pigeonpea (4:2)	7.78	20.52	6.17	18.62	6.98	19.57	19.57	1.13	18.58	20.02
C.D. (P=0.05)	2.89	3.15	2.87	1.60	2.88	2.50	2.88	3.08	2.88	2.98

P.P. = Pigeonpea, S.B. = Soybean.

Table 2. Monetary returns as influenced by intercropping patterns of planting

Treatment	Gross returns (Rs./ha)			Net returns (Rs./ha)			Benefit: cost ratio	
	1997		1998	1997		1998	Mean	
	1997	1998	Mean	1997	1998	Mean		
Sole pigeonpea (60 cm)	31824	29754	30789	15069	12999	14034	1.84	
Sole pigeonpea paired rows (30/90 cm)	31500	30672	31086	14745	13917	14331	1.86	
Sle soybean (45 cm)	36000	30048	33024	16900	10948	13924	1.73	
Pigeonpea + soybean (1:1)	45966	38274	42120	26211	18519	22365	2.13	
Pigeonpea paired rows+soybean (2:1)	42360	38508	40434	23605	19753	21679	2.15	
Pigeonpea paired rows + soybean (2:2)	46728	43668	45198	26973	23913	25443	2.28	
Soybean + Pigeonpea (4:2)	38628	33450	36039	18128	12950	15539	1.76	
C.D. (P=0.05)	5544	5180	5365	5544	5181	5366		

REFERENCES

- Dubey, O.P., Garg, D.C., Dixit, J.P. and Tiwari, K.P., 1991. *Indian J. Agron.*, **36** : 253-254.
- Halvankar, G.B. Varghese Philips, Taware, S.P. and Raut, V.M. 2000. *Indian J. Agron.*, **45** (3) : 530-533.
- Holkar, S., Jagtap, J.G., Billore, S.d. and Mishra, V.K. 1991. *Indan J. Agric. Sci.*, **61** : 93-96.
- Joshi, P.K., Aleemuddin, M. and Mergal, S.D. 1997. *Indian J. Agron.*, **42** : 228-230.
- Prasad, K. and Srivastava, V.C., 1991. *Indian J. Agric. Sci.*, **61** : 243-246.
- Tomar, R.S.S., Upadhyay, M.S. and Sharma, R.A. 1987. *Indian J. Agron.*, **32** : 322-325.
- Willey, R.W. 1979. *Field Crops Abstracts*, **32** : 2-10, 73-81.

STUDIES ON SOME GROWTH PARAMETERS IN COLOCASIA AT DIFFERENT SPACINGS

IRA SARMA

Department of Horticulture
Assam Agricultural University, Jorhat-785 013, Assam

ABSTRACT

Six growth parameters were studied in five *Colocasia* cultivars at different stages of growth in four spacings. It was found that plant height, functional leaves and leaf area index increased upto 120 days after planting and thereafter declined till maturity whereas number of suckers and cormels increased with the age of the crop. Maximum plant height, functional leaves and leaf area index were produced at the spacing of 60×45 cm and the minimum of these parameters were produced at the spacing of 60×35 cm. Greater number of suckers and cormels were obtained at wider spacing i.e. 60×65 cm and lesser number at narrow spacing i.e. 60×35 cm.

Key words : *Colocasia*, growth, spacing.

Colocasia esculenta (L.) Schoot. is one of the most important edible aroids grown throughout the tropics and the subtropics. Investigations conducted with different types of aroids showed that spacing influences not only the yield but also the various growth parameters. Hundreds of cultivars of *Colocasia* are grown in different parts of Assam and its adjoining states and wide variation exists in stature and other growth parameters. The studies delineating the dependence of yield and other growth parameters on levels of spacing are scanty. Therefore, an experiment was carried out to study the pattern of change in the growth parameters in *Colocasia* at different spacings.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during kharif season. The experimental field was well prepared and fertilized with 12 tonnes of FYM, 80 kg N, 60 kg P₂O₅ and 120 kg K₂O per hectare. Half of nitrogen and potash and whole dose of phosphatic fertilizers were applied two days ahead of planting. The remaining half doses of nitrogen and potassic fertilizers were applied one month after emergence of shoot. The normal package for growing of the crop was followed according to the package of practices of Assam.

The experiment was laid out in split-plot design with twenty treatments splitted in two factors i.e. five cultivars (Bor kachu, Ahina black, Mohkhuti, Tekelikachu and Konikachu) as main plots and found spacings (60×35 cm, 60×45 cm, 60×55cm and 60×65 cm) as sub-plots replicated thrice.

RESULTS AND DISCUSSION

Gradual increase in plant height and number of functional leaves were observed upto 120 DAP followed by a gradual decline in both the parameters till maturity in all the cultivars (Table 1). These results were in good agreement with the study conducted by Mohankumar and Sadanandan (1990). Maximum plant height and functional leaves were produced by the cultivar Tekelikachu and the minimum by Borkachu. The decline in plant height with age of the crop might be due to continual turnover of leaves with the older ones dying as new ones appear (Onwueme, 1978). Further tuber development started ahead of 120 DAP demanding more deviation of assimilates for the development of tuber. Thus the photosynthates produced were mostly used up for the development of tubers at the expense of growth of the plant. The variation in functional leaf numbers at different stages of growth might be attributed to be due to difference in varietal characters such as the

Table 1. Plant height and number of functional leaves at 20 days interval

Sources	Plant height						Functional leaves							
	60 DAP	80 DAP	100 DAP	120 DAP	140 DAP	160 DAP	180 DAP	60 DAP	80 DAP	100 DAP	120 DAP	140 DAP	160 DAP	180 DAP
Variety*														
V ₁	26.83	44.89	59.68	66.36	60.35	51.69	41.48	1.68	3.06	3.84	4.31	3.31	2.31	1.61
V ₂	36.37	57.37	75.56	88.75	79.43	74.80	59.55	1.78	3.20	4.03	4.37	3.39	2.35	1.71
V ₃	39.04	58.49	76.98	89.57	80.04	76.19	61.31	1.90	3.38	4.35	4.54	3.60	2.53	1.52
V ₄	43.74	65.77	86.63	99.33	90.59	84.24	69.09	2.09	3.61	4.43	4.71	3.76	2.94	2.10
V ₅	42.93	63.33	80.57	91.27	81.12	77.12	61.82	2.02	3.50	4.37	4.59	3.54	2.55	1.55
C.D. (P=0.05)	0.59	0.56	0.49	0.51	0.29	0.34	0.40	0.06	0.09	0.02	0.02	0.02	0.02	0.02
Spacing**														
S ₁	33.06	53.63	71.83	82.81	81.09	69.11	54.88	1.70	3.15	3.83	4.16	3.11	2.12	1.45
S ₂	41.97	63.39	81.07	91.98	88.31	77.17	62.85	2.36	3.69	4.65	4.91	3.95	3.07	2.07
S ₃	38.17	57.60	77.42	87.53	83.80	73.82	59.46	1.98	3.51	4.38	4.69	3.74	2.71	1.72
S ₄	36.33	55.66	73.21	85.13	81.42	71.13	56.98	1.79	3.21	3.95	4.26	3.29	2.24	1.57
C.D. (P=0.05)	0.28	0.35	0.39	0.33	0.22	0.22	0.23	0.06	0.04	0.04	0.04	0.02	0.04	0.04

DAP = Days After Planting

V₁ = Borkachu; V₂ = Ahina-black; V₃ = Mohkhuti; V₄ = Tekelikachu; V₅ = KonikachuS₁ = 60 × 35 cm; S₂ = 60 × 45 cm; S₃ = 60 × 55 cm; S₄ = 60 × 65 cm

* Mean across spacings, ** Mean across varieties

Table 2. Leaf area index, number of suckers and cornels at 20 days interval

Sources	Leaf area index										Number of suckers										Number of cornels									
	60		80		100		120		140		160		180		200		220		240		260		280		300		320		340	
	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP
Variety*																														
V ₁	0.38	0.61	0.63	0.66	0.63	0.63	0.40	0.50	0.73	1.16	1.42	2.34	2.65	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87	2.87
V ₂	0.39	0.71	0.74	0.77	0.72	0.72	0.41	0.07	0.77	1.27	1.44	2.52	2.69	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
V ₃	0.41	0.73	0.75	0.79	0.73	0.73	0.43	0.08	0.64	1.13	1.32	2.07	2.61	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
V ₄	0.43	0.78	0.79	0.89	0.82	0.82	0.45	0.12	0.81	1.34	1.53	2.69	2.99	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29
V ₅	0.42	0.75	0.77	0.85	0.79	0.79	0.44	0.10	0.78	1.30	1.45	2.66	2.84	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
C.D. (P=0.05)	0.008	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.02	0.02	0.002	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Spacing**																														
S ₁	0.33	0.34	0.35	0.36	0.34	0.34	0.21	0.06	0.55	1.19	0.31	1.98	2.41	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65
S ₂	0.46	1.14	1.17	1.20	1.17	1.17	0.67	0.11	0.73	1.25	1.37	2.39	2.72	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
S ₃	0.43	0.73	0.75	0.77	0.75	0.75	0.48	0.09	0.77	1.30	1.46	2.50	2.92	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
S ₄	0.39	0.49	0.51	0.53	0.50	0.50	0.36	0.07	0.93	1.36	1.66	2.60	3.24	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
C.D. (P=0.05)	0.012	0.010	0.012	0.012	0.012	0.012	0.012	0.006	0.02	0.02	0.010	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

DAP = Days After Planting

V₁ = Borkachu; V₂ = Ahina-black; V₃ = Mohkhuti; V₄ = Tekelikachu; V₅ = KonikachuS₁ = 60 × 35 cm; S₂ = 60 × 45 cm; S₃ = 60 × 55 cm; S₄ = 60 × 65 cm

* Mean across spacings, ** Mean across varieties

growth rate and rate of unfurling at leaves (Onwueme, 1978). It is observed that (Table 1) the spacing differed significantly in respect of plant height and number of functional leaf and the maximum were produced at 60×45 cm and the minimum at 60×35 cm. This might be due to optimum plant population in relation to space, nutrients and light interaction at 60×45 cm spacings while there were more intense interplant competition for space, light and nutrients due to more plant population at 60×35 cm spacing.

It is evident from the Table 2 that the leaf area index of the cultivars differed significantly at different stages of growth. In all the cultivars it increased exponentially upto 120 DAP and thereafter declined gradually with increasing age. The reduction in leaf area index might be due to gradual decrease in functional leaf number as well as leaf size. The highest leaf area index was produced by the cultivar Tekelikachu and the lowest by the cultivar Borkachu. The four spacings differed significantly in respect of leaf

area index. The highest leaf area index was observed at 60×45 cm spacing due to greater size and more number of functional leaves while the lowest was observed at 60×35 cm spacing due to smaller size and less number of functional leaves.

It is also apparent from the Table 2 that there were significant differences in number of suckers and cormels among the cultivars. The highest number of suckers and cormels were produced by the cultivar Tekelikachu while cultivar Mohkhuti produced the lowest. These differences might be due to their differences in suckering habit. The four spacings also differed significantly in respect of number of suckers and cormels. At the widest spacing i.e. 60×65 cm, the number of both suckers and cormels were high which was expected to be due to less plant population. In contrast, the value of both the parameters were found low at the narrowest spacing i.e. 60×35 cm. This might be due to more plant population. This was also in agreement with the findings of Mannan and Rashid (1988).

REFERENCES

- Mannan, M.A. and Rashid, M.M. 1988. Effect of plant spacing on the yield of two panikachu (*Colocasia esculenta*) Lines. *Bangladesh Journal of Agricultural Research*, 13(1) : 57-60.
- Mohankumar, C.R. and Sadanandan, N. 1990. Growth and rooting pattern of taro (*Colocasia esculenta* L. Schott.). *J. Root Crops*, 16(1) : 61-63.
- Onwueme, I.C. 1978. *The Tropical Tuber Crops*. John Wiley and Sons, New York. pp. 199.

EFFECT OF SOURCES AND LEVELS OF PHOSPHORUS WITH AND WITHOUT SEED INOCULATION ON THE PERFORMANCE OF RAINFED CHICKPEA (*CICER ARIETINUM* L.)

B.G. SHIVAKUMAR, S.S. BALLOLI AND C.S. SARAF

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110 012

ABSTRACT

Field experiments to study the suitability of different sources of phosphorus and their levels with and without seed inoculation on the performance of chickpea under rainfed condition, were carried out at the farm of the Indian Agricultural Research Institute, New Delhi. Rock-phosphate as source of phosphorus was as effective as that of single super phosphate in high rainfall year owing to better dissolution in soil as reflected by better growth and yield of chickpea. However, during low rainfall year, single superphosphate was significantly superior to rock phosphate. Increasing levels of phosphorus increased the seed yield significantly irrespective of source of phosphorus. Further the seed inoculation with phosphate solubilizing bacteria (PSB) and *Rhizobium* improved the growth and yield attributes culminating in significantly higher seed yield over that of no seed inoculation.

Key words : Chickpea, phosphorus, rock-phosphate, bio-fertilizers, rainfed condition.

Chickpea (*Cicer arietinum* L.) is cultivated in about 6.31 million hectares area with a total production of 5.08 million tonnes accounting for about 30 per cent area and 38 per cent of total production of pulses in India (GOI, 2001). However, as it is cultivated predominantly under rainfed conditions its productivity is low at 806 kg/ha as against > 2000 kg/ha at research plots (Chaturvedi and Ali, 2002). In spite of being cultivated under rainfed conditions, it removes a sizeable amount of nutrients from soil viz., 44.8 kg N; 14.7 kg P₂O₅ and 53.3 kg K₂O per tonne of grain production (Katyal and Reddy, 1997). Better nutrient management practices hold the key for increased production of this crop under various agro-environmental condition. But due to higher cost of inorganic fertilizers especially phosphatic ones, identification of cheaper sources of phosphorus and their application methods should be explored for encouraging resource poor farmers under rainfed conditions. In soils with low phosphorus, nutrient stress is more dominant than moisture deficiencies, under such situations chickpea responds very well to applied phosphorus and it also increases water use efficiency (Singh and Das, 1987). The conjunctive

use of bio-fertilizers viz., *Rhizobium*, and phosphate solubilizing bacteria (PSB) like *Pseudomonas striata* etc. have synergistic effect on the productivity of pulses (Ahlawat and Shivakumar, 2002). Further the effect of phosphate solubilizing bacteria is greater in phosphorus deficient soils (Tiwari *et al.* 1989). Keeping all these factors in view, an experiment was carried out to study the relative effectiveness of rock phosphate, the cheapest source of phosphorus vis-a-vis single super phosphate at various levels in conjunction with bio-fertilizers under rainfed chickpea.

MATERIALS AND METHODS

Two year field experiment was carried out at the farm of Indian Agricultural Research Institute, New Delhi, during the winter season of 1993-94 and 1994-95 to assess the effectiveness of 2 sources of phosphorus viz., Gafsa rock phosphate (GRP), a low priced imported rock phosphate from Jordan containing 28% P₂O₅ and single super phosphate (SSP) containing 16% P₂O₅ at 3 levels viz., 0, 40 and 80 kg P₂O₅/ha with 2 levels of biofertilizers viz., no seed inoculation and seed inoculation with *Rhizobium*

and phosphate solubilizing bacteria (PSB) viz., *Pseudomonas striata* under rainfed condition. The soil of the experimental field was sandy clay loam in texture, alkaline in reaction (pH 8.0 and EC 0.35 dS/m⁻¹), analyzing low in available nitrogen (O.C. 0.25%) and phosphorus (5 kg P/ha), and high in available potassium (330 kg/ha). The chickpea was sown under high residual moisture condition. There was 869.2, 631.8 and 879.4 mm rainfall during 1993, 1994 and 1995, respectively. Of which about 36.4 mm rainfall during 1993-94 and 100.2 mm during 1994-95 was received in the crop season. The experiment was laid out in randomized block design with three replications. After the layout of the experiment, the phosphorus as per the treatments in the form of GRP and SSP along with a starter dose of 20 kg N/ha in the form of urea was broadcast and incorporated in the experimental plots (6m × 3.6m). The chickpea variety 'Pusa 267' was sown by bullock drawn plough at 30 cm row spacing with a seed rate of 75 kg/ha in the second week of October. Before sowing the seeds were inoculated with appropriate strains of *Rhizobium* and PSB culture and shade dried for about 30 minutes as per the bio-fertilizers treatments. The crop was kept free of weeds by 2 hand weeding at 30 and 60 days after sowing. No plant protection measures were required, as crop was free from insect pests and diseases during its entire growing period till harvest. Observation on various growth and yield attributes were recorded at physiological maturity and yield of grain and stover were recorded after harvest and threshing during the last week of March in both the years. The plant and seed samples collected at harvest were analyzed for P content as per the vanado-molybdo-phosphoric acid yellow colour method (Jackson, 1973). The total uptake was computed by multiplying the content with the yield of seed and stover.

RESULTS AND DISCUSSION

Growth attributes

The pooled analyses of 2 years data indicated a significant increase in plant height and number of branches per plant with GRP as source of phosphorus as compared to SSP. However, the drymatter accumulation did not

show such different influence of sources of phosphorus (Table 1). As drymatter accumulation is an indication of ultimate influence any growth factor, it clearly showed that both SSP and GRP were equally good source of phosphorus even under rainfed conditions.

Among the levels of phosphorus tried, there was increase in all the growth attributes viz., plant height, branches per plant and dry matter accumulation with successive levels of phosphorus up to 80 kg P₂O₅/ha. As the soils under rainfed situations are seldom supplemented with inorganic phosphatic fertilizer, their response to application of phosphorus was quite evident. Further as soils are basically low in available nutrient status, the higher doses also elicit significant crop response in terms of higher vegetative growth.

Between the bio-fertilizer treatments, seed inoculation with *Rhizobium* and PSB recorded significantly higher plant height, number of branches per plant and dry matter accumulation. As soils are exposed to high temperatures during summer, often the beneficial microbes like *Rhizobium* and PSB get killed. Thus seed inoculation shows a significant influence on high biological nitrogen fixation and increased phosphorus availability owing to activity of PSB tend to boost the growth of the crop. It may be due to increased nodulation due to *Rhizobium* inoculation in the presence of phosphorus (Lakshmanarao and Singh, 1983).

There was significant interaction effect between sources and levels of phosphorus on number of branches per plant and dry matter accumulation. The increasing levels of phosphorus significantly increased these traits with GRP as source of phosphorus as compared to SSP indicating that higher levels of GRP could be useful in increasing phosphorus availability to plants due to their lower availability as compared to SSP under rainfed conditions.

Yield attributes

The pooled analysis of the data indicated a significant increase in pod weight per plant and pods per plant with SSP as source of phosphorus as compared to GRP. However, no such

significant difference was noted due to sources of phosphorus on grains per pod, grain weight per plant and test weight of seeds during 1994-95. The difference in pooled analysis were mainly due to differences observed due to sources in 1993-94. In 1994-95, the higher rainfall during crop period might have resulted in increased dissolution of GRP and enhanced the availability of phosphorus at par with that of SSP. However, the differential effect of SSP was substantial enough to show some significant difference in pooled analysis in some yield attributes (Table 2).

All the yield attributes recorded significant increase with each level of phosphorus in both the years as well as in pooled data. It may be attributed to increased availability of phosphorus in both the years as well as in pooled data. It may be attributed to increased availability of phosphorus with each successive dose of phosphorus and its positive effect on growth attributes and subsequently yield attributes.

The seed inoculation with *Rhizobium* and PSB effected significant increase in pod weight per plant pods per plant, grain weight per plant as compared to no seed inoculation. However, grains per pod and test weight of seeds remained unaffected by seed inoculation. Indicating that these traits are generally genetically controlled and are not easily altered by nutritional factors. However yield attributes linked with growth attributes were positively affected by seed inoculation as this could significantly affect those growth attributes.

There was significant interaction effect between sources and levels of phosphorus; and levels of phosphorus and seed inoculation with *Rhizobium* and PSB on pod weight per plant, number of pods per plant and grain weight per plant. In all these, increasing levels of phosphorus with GRP as source recorded higher values. Further seed inoculation recorded higher values of these attributes at lower levels of phosphorus which were comparable with higher levels of phosphorus with no seed inoculation indicating the synergistic effect of sources and levels of phosphorus and levels of phosphorus with seed inoculation on these traits. However, no such interaction effects were noticed on grains per

pod and test weight of seeds.

Yield and harvest index

The grain and stover yield of chickpea was significantly higher with SSP as compared GRP during 1993-94 while during 1994-95 no such differential effect was notice due to sources of phosphorus. The pooled analysis also followed the trend observed during 1993-94. The rainfall during the crop period in 1993-94 was not enough for better dissolution of GRP and subsequent availability of phosphorus to the plants (Table 3).

This was also reflected in lower growth and yield attributes due to GRP application as compared to SSP. However, during 1994-95, following good rainfall, increased dissolution and availability of phosphorus enhanced the effectiveness of GRP. The productivity of chickpea is directly associated with the moisture storage capacity of the soil and the amount of winter rains received during the cropping season. (Singh and Das, 1987). Thus there was no significant difference between SSP and GRP. But the significant positive effect of SSP outweighed the effectiveness of GRP in second year thus still found significantly superior in pooled analysis. The harvest index was significantly higher with GRP as source of phosphorus as compared to SSP during 1993-94. This may be due to the fact that under distress conditions, plants accumulate lower drymatter and divert the photosynthates to reproductive parts resulting in higher grain to straw ratio. The pooled analysis also showed similar pattern. However, during 1994-95, the harvest index was significantly affected by sources of phosphorus.

The increasing levels of phosphorus significantly increased the grain and stover yield and harvest index during both the years indicating that application of higher levels of phosphorus under low moisture conditions is necessary for getting higher yield. Such increase in yield with increasing levels of P_2O_5 was also noticed by Sarawgi *et al.* (2000). This follows the significantly improved growth and yield attributes due to application of phosphorus. When there is increase in growth, it positively influences yield attributes and any improvement in yield attributes result in higher grain and

Table 1. Growth attributes of chickpea at harvest as affected by sources and levels of phosphorus with and without seed inoculation under rainfed condition

Treatment	Plant height (cm)		Branches/plant		Drymatter accumulation (g/pl)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Sources of phosphorus						
SSP	42.93	49.16	5.11	4.33	11.08	11.49
GRP	44.89	51.55	4.97	4.89	10.59	12.79
C.D. at 5%	0.66	NS	NS	0.29	NS	0.82
Levels of phosphorus						
0 kg P ₂ O ₅ /ha	42.29	47.66	4.21	4.16	8.90	10.69
40 kg P ₂ O ₅ /ha	43.61	50.79	5.04	4.54	10.84	12.33
80 kg P ₂ O ₅ /ha	45.82	52.62	5.87	5.12	12.76	13.40
C.D. at 5%	0.81	3.55	0.30	0.35	0.70	1.01
Seed inoculation						
Control	43.63	48.89	4.83	4.36	12.76	11.41
PSB+ <i>Rhizobium</i>	44.19	51.83	5.25	4.86	10.36	12.88
C.D. at 5%	NS	2.90	0.25	0.29	0.57	0.82

Table 2. Yield attributes of chickpea at harvest as affected by sources and levels of phosphorus with and without seed inoculation under rainfed condition

Treatment	Pod weight/plant (g)		Pods/plant		Grains/pod		Grain weight/plant (g)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Sources of phosphorus								
SSP	6.36	6.51	42.20	45.78	1.01	0.99	2.79	3.21
GRP	5.65	6.58	36.61	46.86	1.00	1.01	2.54	3.30
C.D. at 5%	0.41	NS	1.86	NS	NS	NS	0.21	NS
Levels of phosphorus								
0 kg P ₂ O ₅ /ha	3.70	4.85	23.96	36.75	0.95	0.95	1.40	2.26
40 kg P ₂ O ₅ /ha	6.09	6.42	40.88	46.91	1.02	1.01	2.72	3.25
80 kg P ₂ O ₅ /ha	8.23	8.37	53.37	55.29	1.06	1.05	3.87	4.25
C.D. at 5%	0.51	0.35	2.28	2.41	0.02	0.03	0.26	0.20
Seed inoculation								
Control	5.69	6.20	37.25	43.97	1.01	0.99	2.44	3.00
PSB+ <i>Rhizobium</i>	6.23	6.89	41.56	48.67	1.01	1.01	2.89	3.51
C.D. at 5%	0.41	0.29	1.86	1.97	NS	NS	0.21	0.16

Table 3. Test weight, grain yield, stover yield and harvest index as affected by sources and levels of phosphorus with and without seed inoculation under rainfed condition

Treatment	Test weight (g/100 seed)			Grain yield (q/ha)			Stover yield (q/ha)			Harvest index (%)		
	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean
Sources of phosphorus												
SSP	6.46	6.90	6.68	9.26	10.70	9.71	15.79	17.87	16.83	36.40	36.00	36.20
GRP	6.72	6.87	6.80	8.45	9.92	9.18	13.73	17.43	15.58	37.69	36.03	36.86
C.D. at 5%	NS	NS	NS	0.68	NS	0.41	1.12	NS	0.64	0.55	NS	0.38
Levels of phosphorus												
0 kg P ₂ O ₅ /ha	6.44	6.47	6.45	4.65	7.72	6.19	8.51	14.76	11.64	35.27	34.34	34.80
40 kg P ₂ O ₅ /ha	6.54	6.89	6.72	9.08	10.07	9.57	15.57	18.23	16.90	36.89	35.56	36.22
80 kg P ₂ O ₅ /ha	6.79	7.29	7.04	12.84	12.33	12.58	20.18	19.96	20.07	38.98	38.15	38.56
C.D. at 5%	NS	0.14	0.29	0.83	0.52	0.50	1.37	0.89	0.79	0.68	1.12	0.50
Seed inoculation												
Control	6.50	6.77	6.63	8.10	9.46	8.77	13.78	17.09	15.43	36.46	35.43	35.94
PSB+ <i>Rhizobium</i>	6.68	7.00	6.84	9.62	10.63	10.12	15.74	18.21	16.97	37.63	36.60	37.11
C.D. at 5%	NS	0.11	NS	0.68	0.42	0.41	1.12	0.72	0.64	0.55	0.72	0.38

Table 4. Phosphorus uptake by chickpea as affected by sources and levels of phosphorus with and without seed inoculation under rainfed condition

Treatment	Grain (kg/ha)			Stover (kg/ha)			Total (kg/ha)		
	1993-94	1994-95	Mean	1993-94	1994-95	Mean	1993-94	1994-95	Mean
Sources of phosphorus									
SSP	3.42	3.84	3.63	3.54	3.98	3.76	6.98	7.82	7.40
GRP	3.09	3.72	3.40	3.03	3.84	3.44	6.14	7.56	6.85
C.D. at 5%	0.25	NS	0.15	0.29	NS	0.15	0.55	NS	0.29
Levels of phosphorus									
0 kg P ₂ O ₅ /ha	1.65	2.78	2.22	1.81	3.15	2.48	3.49	5.93	4.71
40 kg P ₂ O ₅ /ha	3.31	3.78	3.55	3.49	4.06	3.77	6.80	7.84	7.32
80 kg P ₂ O ₅ /ha	4.80	4.78	4.79	4.55	4.53	4.54	9.39	9.31	9.35
C.D. at 5%	0.31	0.19	0.18	0.36	0.19	0.20	0.67	0.35	0.35
Seed inoculation									
Control	2.95	3.52	3.24	3.02	3.75	3.38	6.02	7.27	6.65
PSB+ <i>Rhizobium</i>	3.56	4.03	3.80	3.55	4.07	3.81	7.11	8.11	7.61
C.D. at 5%	0.25	0.15	0.15	0.29	0.16	0.15	0.55	0.30	0.29

stover yield. As both vegetative growth and reproductive growth exhibited increasing trend, the harvest index also increased significantly.

The seed inoculation with *Rhizobium* and PSB too brought about significant increase in grain yield and stover yield, and harvest index. This may be attributed to positive effect of seed inoculation on growth and yield that subsequently culminated in significant increase in both grain and stover yield, and harvest index. Such positive effect of inoculation with *Rhizobium* and PSB on grain yield was also observed by Sarawgi *et al.* (2000) under rainfed conditions.

Further there was significant interaction effect between sources of phosphorus and seed inoculation with *Rhizobium* and PSB, and levels of phosphorus and seed inoculation. The grain and stover yield was significantly higher with GRP as source of phosphorus with seed inoculation compared to no seed inoculation. Prabhakar and Saraf (1990) also reported that the Mussorie rock phosphate in conjunction with PSB was as effective as SSP. The seed inoculation with *Rhizobium* and PSB recorded significantly higher grain yield at lower levels of phosphorus as compared to no inoculation.

Phosphorus uptake

The uptake of phosphorus in grain, stover and total was significantly higher when it was applied in the form of SSP during 1993-94 and in pooled analysis. However, during 1994-95, the uptake of phosphorus in grain and stover and total was not influenced by the sources as both

SSP and GRP were equally available due to good rains received during crop period. Since moisture is the limiting factor under rainfed conditions increased moisture availability besides being quite useful to the crop, enhances the availability of nutrients specially the phosphorus which is otherwise fixed and immobile in soil.

The increasing levels of phosphorus also recorded significant uptake of phosphorus with each successive level. This may be due to higher phosphorus availability with increasing levels of phosphorus application. The seed inoculation with *Rhizobium* and PSB too brought about significant increase in uptake of phosphorus in grain, stover and total as compared to no seed inoculation. This can be attributed to dissolution and mobilization of fixed phosphorus in soil to the crop plants by PSB and its synergistic effect with increased nodulation following *Rhizobium* inoculation.

There was significant interaction effect between sources of phosphorus and seed inoculation, and levels of phosphorus and seed inoculation on the phosphorus uptake in grain, stover and total. Seed inoculation significantly increased the uptake of phosphorus with GRP as source of phosphorus and the uptake of phosphorus was significantly higher with lower levels of phosphorus with seed inoculation as compared to no seed inoculation. Sarawgi *et al.* (1999) also reported such positive effect of inoculation and phosphorus application on nitrogen and phosphorus uptake and seed crude protein content.

REFERENCES

- Ahlawat, I.P.S. and Shivakumar, B.G. 2002. Nutrient management in pulse crops. *In* : Nutrient Management Recommendations for Pulses and Oilseeds (Ed. H.L.S. Tandon). Fertilizer Development and Consultancy Organization, New Delhi. pp. 32-65.
- Chaturvedi, S.K. and Ali, M. 2002. Poor man's meat needs fresh fillip. *In* : Survey of Indian Agriculture. The Hindu, Chennai. pp. 63-69.
- GOI, 2001. Agricultural Statistics at a Glance. Directorate of Economics and Statistics. Ministry of Agriculture, New Delhi. p. 245.
- Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.
- Katyal, J.C. and Reddy, K.C.K. 1997. Plant nutrients supply needs : Rainfed food crops. *In* : Plant Nutrient Needs, Supply Efficiency and Policy Issues 2000-2025 (Eds. J.S. Kanwar and J.C. Katyal). National Academy of Agricultural Sciences, New Delhi. pp. 91-113.
- Lakshmanarao, K. and Singh, K. 1983. Effect of phosphorus and bio-fertilizer on leghemoglobin and N fixation of chickpea. *Madras Agricultural Journal*, 70 : 572-577.

- Prabhakar, M. and Saraf, C.S. 1990. Drymatter accumulation and distribution in chickpea (*Cicer arietinum*) as influenced by genotypes, phosphorus sources and irrigation levels. *Indian Journal of Agricultural Sciences*, 60 : 204-206.
- Sarawgi, S.K., Tiwari, P.K. and Tripathi, R.S. 1999. Uptake and balance sheet of nitrogen and phosphorus in gram (*Cicer arietinum*) as influenced by phosphorus bio-fertilizer and micronutrients under rainfed conditions. *Indian Journal of Agronomy*, 44 : 768-772.
- Sarawgi, S.K., Tiwari, P.K. and Tripathi, R.S. 2000. Growth, nodulation and yield of chickpea as influenced by phosphorus, bacteria culture and micronutrients under rainfed conditions. *Madras Agricultural Journal.*, 86 : 181-185.
- Singh, R.P. and Das, S.K. 1987. Management of chickpea and pigeonpea under stress conditions with particular reference to drought. Adaptation of chickpea and pigeonpea to abiotic stress. Proc. 'Consultants Workshop' held at ICRISAT Centre, India. 19-20 December 1984. pp. 51-61.
- Tiwari, V.N., Lehri, L.K. and Pathak, A.N. 1989. Effect of inoculating crops with phosphomicrobes. *Experimental Agriculture*, 25 : 47-50.

EFFECT OF INTEGRATED SOURCES OF NITROGEN ON YIELD OF AROMATIC RICES AND THEIR RESIDUAL EFFECT ON SUCCEEDING WHEAT CROP

N.P. ADHIKRI AND B.N. MISHRA

*Department of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

An experiment was laid out during 2000-01 at the Indian Agricultural Research Institute, New Delhi with newly released aromatic rice variety 'Pusa Sugandh-3' and the conventional high quality aromatic rice variety Basmati-370. These two varieties and nine combinations of nitrogen (Table 1) were laid out in RCBD factorial design with 3 replications. After the harvest of rice, wheat variety HD 2329 as a succeeding crop was grown with 50% recommended dose of N.

Aromatic rice variety Pusa Sugandh-3 proved significantly superior than Basmati-370 and produced almost the double grain yield. An increase in the levels of nitrogen from 0 to 120 kg/ha increased the yield of Pusa Sugandh-3 by 70% and that of Basmati 370 by 54% indicating Pusa Sugandh-3 more responsive of N application.

Interaction effect study further indicated that the yield of Pusa Sugandh-3 without N application was similar to that obtained from Basmati-370 at 120 kg N/ha. Application of nitrogen either through prilled urea or in combination with other organic sources gave significantly higher yield of Basmati-370 than the yield of obtained at 0 kg N/ha. While yields at

120 kg N/ha through prilled urea or combined organic-organic nitrogen treatments were higher than at 60 kg N/ha through prilled urea in Pusa Sugandh-3. Since yields of integrated nitrogen management treatments were at par with 120 kg N/ha through prilled urea. It can be inferred that 50% of required nitrogen can be substituted through organic sources.

Organic sources of N applied or rice resulted significant residual effect on the productivity of succeeding wheat. All the organic sources. FYM, vermicompost and combination of vermicompost with BGA plus inorganic fertilizer N applied to rice were superior to supply of N through prilled urea alone in case of wheat yield. Wheat yield was significantly highest when 50% N for rice was substituted by FYM. Mishra and Prasad (2000) also observed significant residual effect of organic sources of N applied to rice on succeeding wheat.

CONCLUSION

FYM, vermicompost and combination of FYM and BGA were able to substitute 50% N needs of aromatic rice with significant residual effect on succeeding wheat.

Table 1. Effect of integrated sources of nitrogen on the grain yield of aromatic rices and their effect on succeeding wheat crop

Treatments	Yield (q/ha)			
	Rice-2000		Wheat 2000-01	
	Basmati 370	Pusa Sugandh-3	After Basmati-370	After Pusa Sugandh-3
0 kg N/ha	24.9	38.2	30.0	30.7
60 kg N/ha - PU	29.1	52.7	30.9	30.6
120 kg N/ha - PU	38.4	64.6	32.2	32.8
80 kg N/ha - PU + 40 kg N/ha - FYM	32.7	63.5	36.8	37.0
60 kg N/ha - PU + 60 kg N/ha - FYM	33.7	59.9	41.5	40.6
80 kg N/ha - PU + 40 kg N/ha vermicompost	36.2	62.7	36.5	39.8
60 kg N/ha - PU + 60 kg N/ha vermicompost	38.8	63.5	36.6	37.8
80 kg N/ha - PU + 20 kg N/ha FYM + BGA	36.1	65.5	39.1	39.1
80 kg N/ha - PU + 40 kg N/ha FYM + BGA	34.4	66.4	38.6	39.5
C.D. (0.05)	5.1			

REFERENCES

- Bhasin, V.K. 2000. India and the emerging global rice trade. In : Aromatic Rices. Oxford & IBH. New Delhi. pp. 257-276.
- Mishra, B.N. and Prasad, R. 2000. Integrated nutrient management for sustained production in a rice-wheat cropping system. *Acta Agronomica Hungarica*, 48 : 257-262.

EFFECT OF MICRONUTRIENTS FERTILIZATION ON PRODUCTIVITY POTENTIAL OF URDBEAN (*PHASEOLUS MUNGO* L.)

P.K. SALAM, R.S. RAJPUT, P.K. MISHRA, ANITA AND G.K. SHRIVASTAVA

*Department of Agronomy
College of Agriculture, IGAU, Raipur-492 006*

Field experiment was conducted during kharif of 2001 at instructional farm, Indira Gandhi Agricultural University Raipur (Chhatisgarh). The experiment was laid out in Randomized Block Design (RBD) with three replication. The treatments consisted of ten nutrient management involving macro and micronutrients (Table 1). Urdbean variety TAU-2 with seed rate of 20 kg ha⁻¹ was sown on 14th July 2001 with row spacing of 30 cm.

The seed yield of urdbean under application of N, P₂O₅, K₂O, S @ 20-50-20-20 kg ha⁻¹ i.e. T₂ + borax @ 10 kg ha⁻¹ (T₆) was maximum and comparable yield was also obtained under treatments T₂ + ZnSO₄ @ 25 kg ha⁻¹ (T₄), T₂ + Borax @ 5 kg ha⁻¹ (T₅), T₂ + Sodium molybdate @ 2 kg ha⁻¹ (T₈) and T₂ + Ferrous sulphate @ 2 kg ha⁻¹ (T₁₀) (Table 2). The beneficial effects of Zn, B, Mo etc. for yield enhancement in legumes have reported by Devrajan and Palaniappan (1995) and Dhane and Shukla (1995). The higher yield under treatment T₂ - Borax @ 10 kg ha⁻¹ (T₆) was because of significantly higher growth

i.e. LAI, root length and root nodules and yield attributes particularly pod & plant⁻¹, seed pod⁻¹, test weight seeds plant⁻¹, pod weight plant⁻¹ and seed weight plant⁻¹ (Table 1). Vairavan *et al.* (2002) revealed that application of micronutrients along with the recommended dose of NPKS (25:50:20:20 kg ha⁻¹) recorded significantly higher yield and yield attributes of red gram than application of recommended dose of NPKS alone. Inducement of enzyme activation, root nodulation an arresting flower drop (Vairavan *et al.* 1997) due to micronutrient application might be the reason for higher yield and yield attributes in red gram than application of NPKS alone. Similar observation on the improvement on yield and yield attributes in mungbean by application of ZnSO₄ was reported by Tandon (1991) and Vairavan *et al.* (1997). Further, the involvement of micronutrients viz., zinc, iron and boron in metallo enzyme systems, regulatory functions in auxin production, chlorophyll content and uptake of major nutrients might be the reason for yield improvement.

Table 1. Growth and yield attributes of urdbean as influenced by micronutrient fertilization

Treatments	Dry matter accumulate at 60 DAS (g/plant)	Pods plant ⁻¹ , no.	Seed pod ⁻¹ , no.	100-seed weight, g	Seeds plant ⁻¹ , g	Pod weight plant ⁻¹ g	Seed weight plant ⁻¹ g
T ₁ - No macro and micro-nutrient	7.65	20.57	3.75	3.45	77.14	3.33	2.66
T ₂ - N, P ₂ O ₅ , K ₂ O, S @ 20-50-20-20 kg ha ⁻¹	9.23	26.58	4.12	3.52	109.50	4.82	3.85
T ₃ - T ₂ ZnSO ₄ @ 15 kg ha ⁻¹	10.87	30.33	4.69	3.71	142.25	6.60	5.28
T ₄ - T ₂ + ZnSO ₄ @ 25 kg ha ⁻¹	13.88	35.12	5.87	3.85	206.15	9.92	7.94
T ₅ - T ₂ + Borax @ 5 kg ha ⁻¹	11.23	32.35	5.27	3.79	170.48	8.08	6.46
T ₆ - T ₂ + Borax @ 10 kg ha ⁻¹	16.81	35.25	6.10	3.87	215.03	10.35	8.28
T ₇ - T ₂ + Sodium molybdate @ 1 kg ha ⁻¹	8.75	27.35	4.33	3.61	118.43	5.34	4.28
T ₈ - T ₂ + Sodium molybdate @ 2 kg ha ⁻¹	10.95	31.59	5.12	3.73	161.74	7.54	6.03
T ₉ - T ₂ + Ferrous sulphate @ 1 kg ha ⁻¹	10.15	29.21	4.57	3.65	133.49	6.06	4.87
T ₁₀ - T ₂ + Ferrous sulphate @ 2 kg ha ⁻¹	16.57	34.59	5.39	3.82	186.44	9.80	7.12
SE m±	0.40	1.06	0.15	0.07	5.86	0.26	0.28
C.D. (P=0.05)	1.19	3.15	0.45	0.21	17.40	0.77	0.83

Table 2. Seed and stover yield, harvest index, productivity rating index and production efficiency of urdbean as influenced by micronutrient fertilization

Treatments	Seed yield q/ha-1	Stover yield, q ha-1	Harvest index, %	Productivity rating index %	Production efficiency kg ha-1 day-1
T ₁ - No macro and micro-nutrient	4.85	14.11	25.57	40.42	7.35
T ₂ - N, P ₂ O ₅ , K ₂ O, S @ 20-50-20-20 kg ha ⁻¹	7.63	21.53	26.17	63.58	11.22
T ₃ - T ₂ ZnSO ₄ @ 15 kg ha ⁻¹	8.19	21.57	27.52	68.25	11.70
T ₄ - T ₂ + ZnSO ₄ @ 25 kg ha ⁻¹	8.57	21.27	27.72	71.42	11.90
T ₅ - T ₂ + Borax @ 5 kg ha ⁻¹	8.39	21.55	28.02	69.92	11.82
T ₆ - T ₂ + Borax @ 10 kg ha ⁻¹	9.07	21.90	29.28	75.58	12.60
T ₇ - T ₂ + Sodium molybdate @ 1 kg ha ⁻¹	7.90	21.74	26.65	65.83	11.45
T ₈ - T ₂ + Sodium molybdate @ 2 kg ha ⁻¹	8.29	21.62	27.72	69.08	11.62
T ₉ - T ₂ + Ferrous sulphate @ 1 kg ha ⁻¹	8.06	21.73	27.06	67.17	11.68
T ₁₀ - T ₂ + Ferrous sulphate @ 2 kg ha ⁻¹	8.48	21.53	28.26	70.67	11.94
SE m±	0.29	0.69	0.95	2.53	0.41
C.D. (P=0.05)	0.86	2.05	2.82	7.51	1.22

REFERENCES

- Devrajan, R. and Palaniappan, S.P. 1995. Zinc and Molybdenum on yield and nutrition of soybean. *Madras Agric.*, 82(2) : 188-189.
- Dhane, S.S. and Shukla, L.M. 1995. Distribution of DTPA extractable Zn, Cu, Mn and Fe in some soil series of Maharashtra. *J. Indian soc. Soil Sci.*, 43(4) : 579-600.
- Tandon, H.L.S. 1991. Secondary and Micronutrients in Agriculture guide book cum directory, FOCO, New Delhi. pp. 48.
- Vairavan, K., Ramasamy, M. and Srinivasan, K. 1997. Studies on the effect of micronutrients in urdbean. *Indian J. Pulse Res.*, 10 : 252-253.
- Vairavan, K. Singh, D.R. and Ganecha, C. 2002. Influence of zinc, boron and molybdenum on red gram yield. *Madras Agric. J.*, 89 (4-6) : 365-366.

INFLUENCE OF SOURCES AND LEVELS OF PHOSPHORUS WITH AND WITHOUT PHOSPHORUS SOLUBILIZING BACTERIA (PBS) SEED TREATMENT ON GROWTH AND YIELD OF SOYBEAN (*GLYCINE MAX L.*)

B.G. SHIVAKUMAR AND S.N. SIDRAMAPPA

*Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

Soybean is one of the emerging oil seed crops of India. In recent times its area and production has increased substantially and stands next only to groundnut and rapeseed mustard in importance in India. Being an exhaustive oil seed crop it requires a large quantity of nutrient, particularly phosphorus for proper root growth and pod development. Due to decontrol of phosphatic fertilizers, the cost of has gone up substantially which is causing much hardship to the farmers. In view of this, there is not only a need to find out the cheap source of phosphatic fertilizer suitable for soybean but also devise means to increase the efficiency of applied phosphorus in the soil. Therefore, the present experiment was carried out to evaluate the best source and levels of phosphorus with and without phosphorus solubilizing bacterial seed treatment on the growth and yield of soybean.

Field experiment was conducted at the Indian Agricultural Research Institute, New Delhi. Experimental field was medium in organic carbon content (0.70%), low in available phosphorus (9.0 kg/ha) with a pH 8.0. The treatments consisted of combination of 2 levels of seed treatment viz. no seed treatment and seed treatment with PSB; 2 sources of phosphorus viz. di-ammonium phosphate (DAP) and rock phosphate (RP); and 3 levels of phosphorus viz. 0.20 and 40 kg P_2O_5 /ha. These treatments were tried in randomized block design and replicated thrice. The phosphorus was applied as per treatments a day before sowing alongwith recommended dose of nitrogen and potassic fertilizers uniformly to all the plots on the same day. The PSB seed inoculation was given to half the quantity of seeds and dried under shade. Soybean cv. Pusa 22 was sown on 3

August, about 18 late from normal sowing time due to aberrant wether conditions prevailed in July month.

Application of phosphorus in the form DAP resulted in higher plant height. Sources of phosphorus did not significantly differ with respect to number of branches per plant and dry matter production. However DAP recorded more number of pods per plant, test weight of seed, and higher grain yield as compared to RP. The difference were however statistically non-significant. Higher yield parameters and yield might be due to better solubility of DAP in neutral and saline soils than rock phosphate.

Levels of phosphorus did not significantly influence the plant height. Similar trend was noticed with regard to number of branches per plant. At harvest 40 kg P_2O_5 /ha recorded the highest dry matter production per plant which was significantly superior to 0 and 20 kg P_2O_5 /ha. Since phosphorus plays an important role in root development and translocation of photosynthates and also constituent of nucleic acids, phyton and photopholipids, its application increase different growth parameters. Kumar and Rao (1991) also reported similar results. Grain yield was significantly higher at 40 kg P_2O_5 /ha as compared to 0 and 20 kg P_2O_5 /ha. It may be attributed to higher number of pods/plant and test weight of seeds. The findings are in agreement with Mohd. Abbas et al. (1994). Application of phosphorus in deficient soil increases concentration of 'P' ions of soil solution and ultimately affects formation of more nodules, vigorous root development, better N-fixation and overall better development of plant. This ultimately results in improved yield

Table 1. Influence of sources and levels of phosphorus with and without PSB on growth and yield attributes and yield of soybean

Treatment	Plant height (cm)	Branches / plant	Dry matter (g/pl)	Pods/ plant	100 seed weight (g)	Grain yield (q/ha)	Stover yield (q/ha)
Sources of phosphorus							
DAP	53.6	6.58	37.7	65.4	18.7	10.43	19.09
RP	51.4	6.61	36.0	63.3	18.6	10.22	18.98
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
Levels of phosphorus (kg P₂O₅/ha)							
0	50.0	6.35	34.9	60.9	18.5	9.88	18.7
20	50.8	6.72	35.3	63.0	18.7	9.94	18.9
40	49.0	6.71	41.4	69.2	18.8	11.16	19.5
C.D. at 5%	NS	NS	2.32	NS	NS	1.08	NS
Seed treatment							
PSB	54.0	6.6	37.5	64.3	18.8	10.4	19.24
No PSB	50.9	6.5	36.3	64.4	18.5	10.2	19.04
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS

attributes and increased yield.

The PSB seed treatment recorded maximum plant height at harvest than no PSB, probably due to better availability of phosphorus to plants as bacterial culture aids in dissolution of unavailable phosphorus in the soil. However the number of branches per plant were more or less similar in both the treatments. The dry matter

production per plant was slightly higher in PSB, but it was not significantly different from no PSB inoculation. Similar results were also reported with respect to number of pods/plant, test weight of seeds, grain and straw yields. The results are in conformity with the findings of Gopalkrishnan and Palaniappan, (1992). However, the interaction effects among different treatments were found non-significant.

REFERENCES

- Gopalkrishnan and Palaniappan, S. 1992. Effectiveness of Mussorie rock phosphate with solubilizing agents in soybean. *Indian J. Agric. Sci.*, 62 (6) : 387-39.
- Kumar, K. and Rao, K.V.P. 1991. Nitrogen and phosphorus levels in relation to drymatter production, phosphorus uptake and their partitioning in soybean. *Ann. Agric. Res.*, 12(3) : 270-272.
- Mohd. Abbas, Singh, M.P. and Nigam, K.P. and Kandalkar, V.S. 1994. Effect of phosphorus, plant densities and plant type on yield and yield attributing characters of soybean (*Glycine max* L.). *Indian J. Agron.*, 39(2) : 248-251.

EFFECT OF DATE OF SOWING, ROW SPACING AND WEED CONTROL PRACTICES ON WEED GROWTH AND PRODUCTIVITY IN SOYBEAN

DHEERAJ PANDEY, DHEER SINGH AND P.K. TOMAR

Department of Agronomy
G.B. Pant University of Agriculture and Technology,
Pantnagar-263145, U.S. Nagar, Uttranchal

A study was conducted during 2001 at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of date of sowing, row spacing and weed control practices on weed growth and productivity of soybean. Date of sowing and row spacing were assigned to main plot and weed control practices to sub plots.

Echinochloa colonum was found to be the most predominant among grassy weeds and contributed highest weed population at all the stages of crop growth (Table 1). Among non grassy weeds commelina benghalensis and among sedges (*Cyperus rotundus*) population was influenced significantly by date of planting and row spacing only at 60 days stage of crop growth. Optimum planting (5th July) resulted in significantly higher weed density as compared to delayed planting (20th July). Weed control efficiency (WCE) was higher in optimum planting (61.06%) with respect to delayed planting (45.99%) (Table 2). Row spacing did not exert significant influence on weed density and weed dry matter. However, higher WCE was recorded in narrow row spacing (30 cm) as compared to wider row spacing (60 cm). Metribuzine @ 1.0 kg ha⁻¹ recorded lowest weed density (22.0 m⁻²) and weed dry matter (53.07 gm⁻²) which was significantly lower as compared to other weed management practices. This was also evident by the highest WCE of Metribuzine @ 1.0 kg ha⁻¹ (81.87%) followed by Pendimethalin @ 1.5 kg ha⁻¹ (48.18%) and Alachlor @ 2.0 kg ha⁻¹ (37.61%).

In general, higher grain yield was recorded in optimum planting date (5th July) and narrow row spacing (30 cm). Raghuvanshi *et al.* (1988) also observed that soybean sown in first week of July produced higher grain yield as compared to that sown in last week of July. Weed free Metribuzine @ 1.0 kg ha⁻¹ resulted in almost similar grain yield which was significantly higher as compared to other weed control practices (Table 3). Various yield contributing characters were also found to be significantly higher under optimum planting (5th July) as compared to delay planted (20th July). However they were not significantly affected by row spacing. Metribuzine @ 1.0 kg ha⁻¹ and weed free treatment resulted in higher number of pods per plant, grain per pod and 1000-grain weight as compared to other weed management methods. Natrajan *et al.* (1997) also reported similar findings.

Highest grain yield in treatment of weed free plot followed by Metribuzine @ 1.0 kg ha⁻¹ over weedy check were the result of less crop weed competition due to less weed population and low weed dry matter (Table 2). These were information with the findings of Bhan *et al.* (1974). Thus, narrowing of soybean row spacing under optimum planting conditions in combination with the pre-emergence application of Metribuzine @ 1.0 kg ha⁻¹ increased soybean yield where excessive weed growth was the principle yield limiting factor.

Table 1. Important weeds species (percentage of total weeds) in soybean field

Weed species	Days after sowing			
	30	60	90	Harvest
<i>Echinochloa colonum</i>	3	44.5	42.5	39.5
<i>Eluesine indica</i>	16.7	13.2	10.9	5.6
<i>Brachiaria mutica</i>	17.6	10.6	21.1	35.3
<i>Commelina benghalensis</i>	8.1	10.3	14.9	15.1
<i>Celosia argentea</i>	8.3	8.8	4.2	3.4
<i>Cyperus rotundus</i>	7.7	8.1	3.6	-
Others	3.3	4.5	2.8	1.1

Table 2. Weed population (No./m²), dry matter of weeds (g/m²) and weed control efficiency (%) as influence by various treatments at 60 days stage growth in soybean

Treatment	Total weeds	Weeds dry matter	Weed control
Date of planting			
Optimum (5th July)	3.09 (49.90)	3.58 (113.95)	61.06
Delayed (20th July)	2.64 (24.25)	4.07 (158.07)	45.99
SEm±	0.06	0.16	-
C.D. at 5%	0.19	0.51	-
Row spacing (cm)			
Narrow (30)	2.85 (36.35)	3.77 (126.92)	56.64
Wider (60)	2.87 (37.80)	3.88 (145.10)	50.42
SEm±	0.06	0.16	-
C.D. at 5%	NS	NS	-
Weed management			
Metribuzine 1.0 kg/ha	2.98 (22.0)	3.61 (53.07)	81.87
Alachlor 2.5 kg/ha	3.29 (28.13)	5.14 (182.61)	37.61
Pendimethalin 1.5 kg/ha	3.71 (43.63)	4.75 (151.59)	48.18
Weed free	0.0 (91.63)	0.0 (292.70)	100.0
SEm±	0.08	0.14	-
C.D. at 5%	0.23	0.39	-

Original data given in parenthesis subjected to log transformation.

Table 3. Seed grain, yield attributes as influenced by various treatments

Treatment	Grain yields (q/ha)	No. of pod per plant	No. of grain /pod	1000- grain weight	Weed index (%)
Date of planting					
Optimum (5th July)	30.49	115.8	2.46	113.2	30.26
Delayed (20th July)	23.90	73.16	2.01	116.6	30.84
SE $\pm$	3.82	2.12	0.08	1.79	-
C.D. at 5%	NS	6.78	0.26	NS	-
Row spacing (cm)					
Narrow (30)	28.21	95.57	2.22	116.45	27.79
Wider (60)	26.29	93.31	2.25	113.35	33.22
SE $\pm$	3.82	2.12	0.08	1.79	-
C.D. at 5%	NS	NS	NS	NS	-
Weed management					
Metribuzine 1.0 kg/ha	32.19	102.40	2.23	113.82	15.37
Alachlor 2.5 kg/ha	26.62	80.02	2.21	112.27	32.02
Pendimethalin 1.5 kg/ha	27.44	95.94	2.21	112.27	32.02
Weed free	33.43	128.73	2.30	121.9	0.0
Weedy	16.59	65.09	2.20	112.5	53.0
SE $\pm$	1.46	4.7	0.07	1.50	-
C.D. at 5%	4.15	1.47	NS	4.28	-

Original data given in parenthesis subjected to log transformation.

REFERENCES

- Bhan, V.M.; Singh M. and Maurya, R.A. 1974. Studies on the requirement of weed free maintenance in soybean. *Indian J. Weed Sci.*, 6(1) : 12-16.
- Dharm, S. Dagger, J.C.; Gangwar, B. and Singh D. 1992. Infestation by weeds and their management in oil seed crops. *Agril. Reviews Karnal.*, 13(3) : 163-175.
- Natrajan, S.; Kuppaswamy, G. and Paneerselvam, S. 1997. Effect of different weed control practices in irrigated soybean. *Madras Agric. Journal*, 84 : (11 & 12) : 650-651.
- Raghuvanshi, R.K.S.; Nem, M.L.; Umat, R. and Thakur, H.S. 1988. Effect of sowing dates and fertility levels on the grain yield of soybean. *Journal Oil Seed Research*, 5(2) : 168-169.

ISSN 0970-3179



*Annals of
Agricultural Research*

New Series Vol. 25

September 2004

Number 3

Published by
The Indian Society of Agricultural Science

INDIAN SOCIETY OF AGRICULTURAL SCIENCE

(Reg. No. S-10231)

EXECUTIVE COUNCIL

<i>Patron</i>	:	M.S. Swaminathan
<i>President</i>	:	Panjab Singh
<i>Vice-Presidents</i>	:	N.N. Singh
	:	R.G. Dani
<i>Secretary</i>	:	R.C. Gautam
<i>Joint Secretary</i>	:	D.S. Mathur
<i>Treasurer</i>	:	B.N. Mishra
<i>Past Presidents</i>	:	M.V. Rao, Prem Narayan,
	:	K.L. Chadha, R.B. Singh

COUNCILLORS

<i>East Zone</i>	<i>West Zone</i>
L.M. Garnayak, Orissa	M.V. Savani, Gujarat
A.K. Patra, Orissa	V.N. Waghmare, Maharashtra
<i>North Zone</i>	<i>South Zone</i>
N.K. Sekhon, Ludhiana	B.N. Reddy, Hyderabad
D.K. Pachauri, New Delhi	H.V. Nanjappa, Bangalore
<i>Central Zone</i>	
H.S. Yadav, M.P.	A.K. Pandey, U.P.

EDITORIAL BOARD

Editor-in-Chief : S.K. Mishra

Editors :

<i>Crop Improvement:</i>	<i>Resource Management:</i>	<i>Crop Protection :</i>	<i>Basic Sciences:</i>	<i>Social Sciences:</i>
B. Sharma	R.K. Rai	Amerika Singh	R.K. Katiyar	R.P. Singh
P.K. Singh	A.K. Dahama	Pratibha Sharma	Rajender Parsad	Poonam Sharma
A.K. Singh	B.G. Shivakumar	Kirti Sharma	G.C. Srivastava	Prem Lata Singh
R.L. Misra	R.N. Garg	Chitra Srivastava	S.M.S. Tomar	A.K. Das
Rajeev K. Sharma	S.K. Singhal	Anil Sirohi	M.K. Rana	Suresh Pal

All correspondences should be addressed to **Dr. R.C. Gautam, Secretary, Indian Society of Agricultural Science, Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110 012.**

Membership	India	Foreign Air Mail
Annual	Rs. 250	US\$40
Life	Rs. 2500	US\$500
Institutional	Rs. 850	US\$250

Discount to publishers 10%

Subscription may be sent by bank draft only. Payable to "Indian Society of Agricultural Science" at New Delhi. Out-station cheques are not accepted.

ANNALS OF AGRICULTURAL RESEARCH

(Organ of the Indian Society of Agricultural Science)

To promote inter-disciplinary research in the field of agriculture and provide a forum for expressing views on policies and programmes relating to agricultural development

CONTENTS

	Page
Effect of phosphorus levels and phosphate solubilizing micro-organisms on PDFE, 'A' value and phosphorus utilization by wheat (<i>Triticum aestivum</i> L.)	Tejpal Singh and R.K. Rai 339
Integrated nutrient management in rainfed castor (<i>Ricinus communis</i>)	Pooran Chand, P.K. Singh and Om Prakash 343
Effect of sowing methods, nitrogen and weed management on quality of <i>Blond psyllium</i> (<i>Plantago ovata</i> Forsk.)	S.K. Kumawat and B.L. Gaur 346
Residual and direct effects of herbicides on weeds and yield of wheat in rice-wheat cropping system	K.A. Gopinath, Jitendra Pandey and B.N. Mishra 350
Influence of moisture conservation and nutrient management on yield, water use efficiency and nutrient uptake of pearl millet (<i>Pennisetum glaucum</i>)	Narendra Kumar and R.C. Gautam 354
Performance of wheat (<i>Triticum aestivum</i>) as influenced by N-management practices in preceding crop of cotton (<i>Gossypium hirsutum</i> L.)	Anup Das, Mangal Prasad and R.C. Gautam 359
Effect of tillage practices and plant population on performance of sunflower	B.N. Reddy and S.N. Sudhakara Babu 363
Weed management in puddle-seeded rice	D.K. Roy 369
Influence of planting patterns and integrated nutrient management on yield, nutrient uptake and quality of rainfed pearl millet	V.S. Rathore, Panjab Singh and R.C. Gautam 373
Analysis of straw and stover of different crops as a livestock feed by the farmers	Nagaratna Biradar 377
Availability of sulphur in some soils of Jharkhand	Brajendra and L.M. Shukla 381

Effect of date of sowing on thermal requirement of <i>Crambe</i>	S.N. Sudhakara Babu, N. Mukta and A.R.G. Ranganatha	384
Studies on aphid dynamics in mustard crop with reference to weather and phenological stages	Sumana Roy, S.K. Prasad and N.V.K. Chakravarty	388
Comparative study of farmer's eye estimate and crop cut estimate for general crop estimation surveys	Tauqueer Ahmad, O.P. Kathuria and Anil Rai	394
Effect of integrated nutrient management on dry matter accumulation nutrient content and uptake by sunflower	K.M. Subha and Gajendra Giri	398
Inheritance of important characters in bacterial wilt resistant $\times$ susceptible tomato (<i>Lycopersicon esculentum</i> Mill.) crosses	K.C. Sharma	403
Genetic variability in urdbean germplasm	Bupesh Kumar and M.N. Mishra	406
Physico-chemical properties of soil and grain yield of rice (<i>Oryza sativa</i>) as influenced by organic and inorganic sources of nutrients	S.S. Parihar	408
Genetic components of variation of physiological attributes for drought screening of genotypes in American cotton (<i>Gossypium hirsutum</i> L.)	A. Narisi Reddy and S. Ratna Kumari	412
Studies on fertigation of mango cv. amrapali	S.K. Thakur and Prabhakar Singh	415
Variation of DTPA-extractable micronutrients with soil properties in semi-arid part of northern Marathwada in Maharashtra	G.U. Malewar, A.L. Dhamak and Syed Ismail	418
Inheritance of root traits associated with drought tolerance in maize	Meena Kumari, Sain Dass, Vimala Y. and Pawan Arora	422
Response of Berseem (<i>Trifolium alexandrinum</i>) to integrated nutrient management	S.K. Sharma and S.N. Sharma	429
Effect of irrigation and antitranspirants on growth and yield of spring sunflower (<i>Helianthus annuus</i> L.)	Ramani Kanta Thakuria, Harbir Singh and Tej Singh	433
Genetics of seed shape in chickpea (<i>Cicer arietinum</i> L.)	H.S. Meena, J. Kumar and S.S. Yadav	439
Impact of direct selection for seed yield on yield components in chickpea (<i>Cicer arietinum</i> L.)	Shoraj Singh, S.K. Mishra and A.K. Ahlawat	442
Identification of yield contributors through path analysis in maize	Arun Kumar and N.N. Singh	448
Evaluation of enriched plant residue compost prepared by utilizing paddy straw and bioinoculants	Livleen Shukla and Rajesh Kumar	451

CONTENTS

iii

Effect of intercropping and integrated nutrient management on growth and yield of mustard and chickpea	<i>R. Tigga, B.S. Joshi, Sanjeev Malaiya and G.K. Shrivastava</i>	453
Leaf growth, chlorophyll, nitrogen content and grain yield of hybrid rice as influenced by planting times and N levels	<i>A.K. Verma, N. Pandey and R.S. Tripathi</i>	456
Response of ragi varieties to nitrogen under rainfed conditions	<i>Raghuvir Singh</i>	459
Impact of nutrient management practices and sorghum based cropping systems on micronutrient dynamics in vertisols	<i>Syed Ismail, G.U. Malewar and M.H. Lomte</i>	461
Response of greengram to sulphur and zinc	<i>Umesh Singh and D.S. Yadav</i>	463
Tillering potential of semi-dwarf wheat varieties under timely sown irrigated condition	<i>U.K. Behera</i>	465

EFFECT OF PHOSPHORUS LEVELS AND PHOSPHATE SOLUBILIZING MICRO-ORGANISMS ON PDFF, 'A' VALUE AND PHOSPHORUS UTILIZATION BY WHEAT (TRITICUM AESTIVUM L.)

TEJPAL SINGH AND R.K. RAI

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

A two year field experiment was conducted to study the effect of phosphorus levels and phosphate solubilizing micro-organisms on PDFF, 'A' value and phosphorus utilization by wheat. The experiment, consisting of 16 treatment combinations, was laid out in factorial randomized block design. Levels of phosphorus as well as inoculation with phosphate solubilizing micro-organisms significantly increased the per cent PDFF. 'A' value increased markedly with successive levels of phosphorus conversely inoculation declined the 'A' value. Combined inoculation with *Pseudomonas striata* + *Aspergillus awamori* registered lowest 'A' value. The per cent utilization of phosphorus declined steadily and significantly with successive levels of phosphorus. While phosphate solubilizing micro-organisms improved the utilization significantly. The highest utilization of phosphorus was recorded when 30 kg P_2O_5 ha⁻¹ supplemented with combined inoculation of *Pseudomonas striata* + *Aspergillus awamori*.

Key words : PDFF, 'A' value, phosphorus utilization, *Pseudomonas striata*, *Aspergillus awamori*, wheat.

Phosphorus is termed as a 'master key' element in crop production. It is second most important essential nutrient element next only to nitrogen and classed along with nitrogen and potassium as major plant nutrient. Phosphatic fertilizers occupy an important place among the non-renewable inputs of modern agriculture, as about 98 per cent of Indian soils have insufficient supply of available phosphorus. Additionally, the major portion of phosphatic fertilizer used in India has to be imported because of low P content of Indian rock phosphates resulting in drain of foreign exchange. Besides the recovery of added P-fertilizers seldom exceed 15-20 per cent. This essentially calls for ways and means to increase efficiency of phosphorus utilization. In this context, use of efficient phosphate solubilizing micro-organisms such as *Pseudomonas striata* and *Aspergillus awamori* as inoculants in the root zone of the crop plant was seed inoculants for increasing the phosphorus use efficiency is of great significance.

MATERIALS AND METHODS

The field experiment was conducted during rabi seasons of 1998-99 and 1999-2000 at the Indian Agricultural Research Institute, New Delhi. The soil of the experimental field was sandy clay loam in texture, low in organic carbon and available nitrogen. The status of available phosphorus was low to medium with higher exchangeable potassium. Wheat variety HD 2329 was raised by following the recommended package of practices to which the experimental treatments consisting of 4 levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha⁻¹) and 4 phosphate solubilizing micro-organisms (no inoculation, *Pseudomonas striata*, *Aspergillus awamori* and *Pseudomonas striata* + *Aspergillus awamori*) were applied. Isotopic phosphorus (³²P) was applied in sample rows. All the treatment combinations were replicated three times in factorial randomized block design. At harvest of plant samples were taken from sample rows. The samples were processed as per

standard procedure to calculate the PDFF, 'A' value and utilization of phosphorus and were calculated as follows :

$$\text{PDFF(\%)} = \frac{\text{Specific activity of plant sample}}{\text{Specific activity of fertilizer standard}} \times 100$$

$$(\text{Specific activity} = \frac{\text{CPm of the sample} - \text{Cpm of the background}}{\text{mg P of the sample}})$$

$$\% \text{ utilization of applied phosphorus} = \frac{\text{Fertilizer P uptake in plant per unit area}}{\text{Fertilizer P applied per unit area}} \times 100$$

$$(\text{Fertilizer P in plants} = \frac{\text{Total P uptake in plant per unit area}}{100} \times \% \text{ Pdff})$$

$$'A' \text{ value (Fried and Dean, 1952; Fried, 1964)} = \frac{\% \text{ P derived by plant from soil (Pdfs)}}{\% \text{ P derived from fertilizer (Pdff)}} \times \text{Rate of fertilizer P applied}$$

RESULTS AND DISCUSSION

PDFF and 'A' value

Levels of phosphorus fertilization had positive relation with phosphorus derived from fertilizer (Table 1). This could be explained in the light of higher absorption of fertilizer due to mass effect as a consequence of which, higher amounts of fertilizer phosphorus found its way in the soil solution and root hairs of crop plants in treated plot. The increase in per cent Pdff was not in tune of successive levels of phosphorus, which might have resulted in soil phosphorus build up. It can easily be viewed in 'A' value which increased markedly with successive levels of phosphorus.

Phosphate solubilizing microorganisms had pronounced positive effect on per cent PDFF (Table 1). Combined inoculation with *Pseudomonas striata* + *Aspergillus awamori* registered highest per cent PDFF (25.71 and 24.41 in first and second year, respectively). As these two micro-organisms produced wide range of organic acid and chelating substances, which effectively solubilize the addition phosphorus and hence improved the PDFF. This explanation could be supported by the 'A' value. Highest 'A' value (97.61 and 99.61 in first and second year, respectively) was recorded without inoculation,

which may be due to very less solubilization of added phosphorus and its consequent addition into the soil pool of the phosphorus. The 'A' value was lowered due to inoculation with phosphate solubilizing micro-organisms. Though 'A' value due to combined inoculation with *Pseudomonas striata* + *Aspergillus awamori*, was lowest but higher uptake and per cent PDFF value proved their solubilizing power on native as well as added phosphorus. These observations further confirmed the results of Rai (1977), Rai *et al.* (1984), Israel (1991) and Modak (1992).

Utilization of phosphorus

The per cent utilization declined steadily and significantly with phosphorus application (Table 2). The reasons attributed to such a decrease in per cent phosphorus utilization are (a) no luxury consumption of phosphorus (as against N and K) with increase in phosphorus levels and (b) increased retention of added phosphorus in soil with increase in the level of P application.

Phosphate solubilizing micro-organisms improved the phosphorus utilization significantly which could be attributed to efficient solubilization of added phosphorus, hence enhanced availability and uptake led to higher biomass production. Phosphorus levels and phosphate solubilizing micro-organisms also

Table 1. Effect of P-levels of phosphate solubilizing micro-organisms on PDFF (%), utilization of phosphorus (%) and 'A' value (kg P ha⁻¹)

Treatments	PdfF (%)		Utilization of phosphorus(%)		A value (kg P ha ⁻¹)	
	1998-99	1999-2000	1998-99	1999-2000	1998-99	1999-2000
Phosphorus (kg P₂O₅ ha⁻¹)						
0	-	-	-	-	-	-
30	21.26	20.19	25.54	22.85	49.07	52.43
60	23.85	23.36	15.87	14.48	84.82	86.94
90	24.62	23.73	11.41	10.20	122.51	128.28
SEm±	0.329	0.325	0.336	0.278	2.107	1.925
C.D. (P=0.05)	0.951	0.940	0.972	0.802	6.086	5.561
Phosphate solubilizing micro-organisms						
No inoculation	20.99	20.49	14.27	13.04	97.61	99.61
<i>Pseudomonas striata</i>	23.45	22.83	17.71	16.16	83.49	86.96
<i>Aspergillus awamori</i>	22.83	21.97	16.83	15.25	87.07	91.48
<i>Pseudomonas striata</i> + <i>Aspergillus awamori</i>	25.71	24.41	21.63	18.92	73.69	78.81
SEm±	0.380	0.376	0.388	0.321	2.433	2.223
C.D. (P=0.05)	1.099	1.086	1.122	0.927	7.028	6.421

Table 2. Interaction effect of treatments on utilization of phosphorus (%)

Phosphate solubilizing micro-organisms	Phosphorus (kg P ₂ O ₅ ha ⁻¹)							
	1998-99				1999-2000			
	0	30	60	90	0	30	60	90
No inoculation	-	20.91	12.68	9.22	-	18.48	10.03	8.62
<i>Pseudomonas striata</i>	-	24.96	16.41	11.78	-	23.28	14.99	10.23
<i>Aspergillus awamori</i>	-	24.32	15.41	10.76	-	22.03	14.12	9.61
<i>Pseudomonas striata</i> + <i>Aspergillus awamori</i>	-	31.97	19.01	13.91	-	27.61	16.80	12.37
SEm±			0.673				0.556	
C.D. (P=0.05)			1.944				1.605	

interacted significantly with regard to utilization of phosphorus. Highest (31.97 and 27.61 per cent in first and second year, respectively) utilization was observed when 30 kg P₂O₅ ha⁻¹ supplemented with combined inoculation of *Pseudomonas striata* + *Aspergillus awamori*. This can

be attributed to higher phosphorus uptake and significantly higher grain yield as noted in this particular treatment. The study further confirmed the observations of Gupta *et al.* (1985) and Negri and Negri (1995).

REFERENCES

- Fried, M. 1964. 'E', 'L' and 'A' values. *Proc. 8th International Congress of Soil Science*, 4 : 29-39.
- Fried, M. and Dean, L.A. 1952. A concept concerning the measurement of available soil nutrients. *Soil Sci.*, 51 : 361-371.
- Gupta, A.P., Khanna, S.S. and Tomar, N.K. 1985. Effect of sodicity on the utilization of phosphatic fertilizer by wheat. *Soil Sci.* 1 : 47-52.
- Israel, S. 1991. Relative efficiency of phosphorus utilization by wheat and gram and its residual effect on forage jowar using ^{32}P as a tracer. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.
- Modak, S.B. 1992. Studies on phosphorus utilization in pigeonpea-wheat sequence using ^{32}P as a tracer. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.
- Negrile, M. and Negrile, E. 1995. Influence of nitrogen and phosphorus fertilizer on wheat yield. *Fundulea*, 62 : 165-175.
- Rai, R.K. 1977. Studies with ^{32}P on phosphorus utilization by maize and wheat in sequence. Ph.D. Thesis, Banaras Hindu University, Varanasi.
- Rai, R.K., Singh, M. and Sinha, M.N. 1984. Phosphorus use efficiency in maize-wheat sequence. *Indian J. Agron.*, 29 : 354-364.

INTEGRATED NUTRIENT MANAGEMENT IN RAINFED CASTOR (*RICINUS COMMUNIS*)

POORAN CHAND, P.K. SINGH AND OM PRAKASH

Regional Agricultural Research Station,
ANGRAU, Palem-509215

ABSTRACT

A field experiment was undertaken to assess the effect of conjunctive use of organic, inorganic and bio-fertilizers, on the productivity of castor under rainfed conditions. The results indicated that applications of 50% R.D.F. (recommended dose of fertilizer) in conjunction with *Azospirillum* seed treatment and application of 25% N through FYM + phosphorus solubilizing bacteria gave higher yield followed by 50% RDF + *Azospirillum* + 25% N through FYM than the rest of the treatments. It can be concluded that organic and inorganic fertilizers can not completely substitute bio-fertilizers. However, conjunctive use of these fertilizers can sustain the productivity.

Key words : Castor, nutrient, bio-fertilizer, green manure, yield.

Oilseed crops are energy rich crops, and obviously the requirement as major nutrients including secondary and micronutrients is very high. Unless the soils are replenished with all the nutrients taken up by the crops, there will be persistent nutrients exhaustion posing a great threat to sustainable oilseeds production. Since, chemical fertilizer alone will not be able to meet the total nutrients needs, integrated use of all potential source of plant nutrients seems to be the only option to maintain soil fertility and crop productivity.

Integrated use of organic, inorganic and bio-fertilizers sustain productivity by improving soil physical condition, such as reducing soil crusting in red soil, increasing water holding capacity, hydration conductivity and infiltration rate besides reducing environmental pollution and may reduce costly inorganic fertilizer needs. In order to assess the effect of conjunctive use of organic (FYM, green manure, neem cake) inorganic fertilizer (25, 50, 75 and 100% RDF) and bio-fertilizer (*Azospirillum* and phosphorus solubilizing bacteria) on the productivity of castor under rainfed conditions, a field experiment was undertaken.

MATERIALS AND METHODS

The experiment was laid out in randomized block design during *kharif*, 2000 and 2001 at

Regional Agril. Research Station, Palem under rainfed conditions with 12 treatments replicated thrice. The treatment comprised of Control (0-0-0), 100% RDF (recommended dose of fertilizer) 75% RDF + 25% N (FYM), 50% RDF + 50% N (FYM), 75% RDF + 25% N (neem cake), 50% RDF+50% N (neem cake), 50% RDF + *Azospirillum* seed treatment + 25% N (FYM), 50% RDF + green manure 50% RDF + 25% N(FYM) + green manure, 50% RDF+25%N (FYM) + 25% N (neem cake), 50% RDF + *Azospirillum* seed treatment + 25% N (FYM) + PSB (*phosphorus solubilizing bacteria*), 25% RDF+25% N (FYM) + 25% N (neem cake) + green manure.

Farm yard manure (FYM) @ 5 t/ha and neem cake @ 0.25 t/ha were applied as band placement. Seed was inoculated with biofertilizer @ 50 g/kg seed. "Kranty" castor variety was sown at a spacing of 90 × 60 cm in a net plot size of 3.6×3.6 m. The soil of the experimental field was sandy loam with 7.2 pH and low in available nitrogen.

Observations on eight important quantitative characters including seed yield and oil content were recorded on five randomly selected plants in each treatment. Harvesting was done at 90, 120 and 150 days after sowing. The pooled data of yield was analysed as per the methods suggested by Panse and Sukhatme (1978).

Table 1. Integrated nutrient management in castor

Treatment/ characters	Plant height (cm)	Length of primary spike(cm)	Nodes upto primary spike	Spikes/ plant	No. of Capsules /spike	100 seed wt.	Cumulative seed yield (kg/h) at DAS			Oil content (%)
							90	120	150	
Control(0-0-0)	60.0	23.9	9.7	5.1	33.3	26.32	298	574	941	46.9
100% RDF	63.8	26.1	9.3	5.2	37.5	26.36	309	830	1151	46.3
75% RDF + 25% N (FYM/5t/ha)	67.3	24.4	10.1	6.7	33.1	25.71	327	892	1267	46.8
50% RDF + 50% N (FYM/5t/ha)	65.3	24.2	10.3	5.3	34.0	26.05	391	985	1349	46.5
75% RDF + 25% N (Neem cake)	62.3	22.6	9.4	6.1	30.1	26.22	415	724	1204	46.3
50% RDF+50% N (Neem cake)	56.7	20.9	8.7	6.8	30.3	26.57	271	669	1189	47.5
50% RDF + Azospirillum seed treatment+25% N (FYM)	53.5	24.8	9.5	6.9	35.3	25.39	508	876	1471	46.2
50% RDF + green manure	45.0	24.3	9.1	6.1	36.8	26.01	402	839	1369	46.9
50% RDF + 25% N(FYM) + green manure	42.9	17.5	10.1	6.9	37.0	25.70	361	772	1389	46.7
50% RDF+25% N (FYM) + 25% N (neem cake)	60.8	23.4	10.3	6.0	29.0	26.96	258	624	1062	46.5
50% RDF + Azospirillum seed treatment+25% N (FYM) + PSB	58.3	26.4	10.4	7.7	35.8	25.09	475	940	1499	47.5
25% RDF+25% N (FYM) + 25% N (neem cake) + green manure	57.9	25.0	10.6	6.5	34.9	26.11	465	947	1417	46.9
S.E _{mt}	2.6	1.76	0.48	0.5	1.3	0.80	29.3	32.8	49.1	0.83
C.D. (0.05)	10.6	7	NS	NS	4.2	NS	112.1	128.7	186	NS
CV (%)	7.9	13.3	8.4	14.5	6.8	5.3	13.6	7.6	6.6	3.0

RESULTS AND DISCUSSION

Results elucidated that application of 50% recommended dose of fertilizer in conjunction with *Azospirillum* seed treatment and applications of 25% N through FYM + phosphorus solubilising bacteria gave higher yield (1499 kg/ha) followed by 50% RDF + *Azospirillum* seed treatment + 25% N through FYM (1417 kg/ha) than rest of the treatments (Table 1). Similar trend was observed in pooled yield also. The increase in yield might be due to increased in primary spike length, more number of capsules in primary spike and enhancement of spikes per plant (Anonymous, 1998). At Palem and Junagarh, also application, of 50% RDF in conjunction with FYM, *Azospirillum* seed treatment and PSB gave substantially higher yield (Anonymous, 1998). It suggests that the conjunctive use of organic, inorganic and biofertilizers might have improved the soil physical conditions and increased nutrient

uptake. Low yield was noticed in the treatment with the application of organic (FYM or neem cake) or in-organic fertilizers alone, without biofertilizers.

The use of 50% RDF + *Azospirillum* seed treatment + 25% N (FYM) + phosphorous solubilizing bacteria resulted in an increased the length of primary spike, more number of spikes per plant and capsules per spike. The number of nodes to primary spike did not differ. The length of spike were less in organic and inorganic fertilizers applied without biofertilizers. The treatments could not alter the test weight of seed and oil content. Similar, results were also reported Baby and Reddy (1998) in castor.

It can be concluded that organic and inorganic fertilizers cannot completely substitute bio-fertilizers. However, conjunctive use of these fertilizers can sustain the productivity.

REFERENCES

- Anonymous 1998. Annual progress report of All India Coordinated Research Project on Castor, DOR, Rajendranagar, Hyderabad.
- Anonymous 1999. Annual progress report of All India Coordinated Research Project on Castor, DOR, Rajendranagar, Hyderabad.
- Baby, Akula and Reddy Bapi, T. 1998, Integrated nutrient management in rainfed castor. *Journal of Oilseeds Research*, 15(1) : 115-117.
- Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.
- Singh, R.P., Das, S.K., Bhaskar, Rao, U.M., and Nagarjuna Reddy, M. 1990. Towards the sustainable Dryland Agricultural practices. Central Research Institute for Dryland Agriculture, Hyderabad.

EFFECT OF SOWING METHODS, NITROGEN AND WEED MANAGEMENT ON QUALITY OF BLOND PSYLLIUM (*PLANTAGO OVATA* FORSK.)

S.K. KUMAWAT AND B.L. GAUR

Department of Agronomy
Rajasthan College of Agriculture
Maharana Pratap University of Agriculture and Technology, Udaipur-313001

ABSTRACT

Results of a field trial conducted on *Blond psyllium* indicated that line sowing at 30 cm row distance recorded significantly higher seed yield over broadcasting. Application of nitrogen at 40 kg ha⁻¹ significantly increased seed yield over 20 kg N ha⁻¹. Increasing levels of nitrogen brought about decrease in husk recovery and swelling factor. Increasing levels up to 60 kg N ha⁻¹ significantly improved protein content in seed. Swelling factor of seed was found maximum under two manual weeding (11.82 ccg⁻¹). The protein content in seed was maximum under isoproturon at 0.75 kg ha⁻¹ + one H.W., closely followed by isoproturon at 0.50 kg ha⁻¹ + one H.W. and two manual weeding.

Key words : Nitrogen, sowing method, weed management.

Blond psyllium (Isabgol) is a winter season medicinal crop. The seed of blond psyllium are mainly valued for mucilaginous rosy white husk. The mucilage comprises of reserve carbohydrates mainly pantosans (Karawya *et al.* 1971). It has a high water absorbing capacity and, therefore, used as safe antidiarrhoeal drug. In recent times interest in this crop has increased in the Western countries because of the blood cholesterol lowering property of its husk (Taneja *et al.* 1989). The seeds without husk are used as cattle feed.

Blond psyllium crop is mostly sown by broadcasting with poor nitrogen fertilization and weed management, leads to poor plant stand, poor plant growth and severe weed competition during early crop growth stage which results in poor yield and quality of the crop.

MATERIALS AND METHODS

The field experiment was conducted at the instructional of farm Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during the winter season of 1998-99 and 1999-2000. The soil was clay loam in texture and alkaline in reaction (pH 7.8). It was medium in available nitrogen (266.50 kg ha⁻¹) and available phosphorous (17.30 kg ha⁻¹) and high in available potassium (388.00 kg ha⁻¹). The experiment was

laid out in split plot design with four replications. The treatments comprise of two sowing methods (broadcasting and line sowing at 30 cm row distance) and three levels of nitrogen (20, 40 and 60 kg ha⁻¹) in main plots and five weed management treatments (pre-emergence application of isoproturon at 0.25, 0.50 and 0.75 kg ha⁻¹ + one hand weeding at 45 DAS, two manual weeding at 25 and 45 DAS and unweeded check) in subplot. The fertilizer phosphorus and half of N as per the treatment was drilled at the time of sowing, whereas, remaining half dose of N was top dressed at 30 days after sowing. *Blond psyllium* cultivar 'GJ-2' was used as test variety. The crop was sown on 23th and 25th Nov. during two years as per the treatments, using a uniform seed rate of 6 kg ha⁻¹.

The husk recovery and swelling factor of *Blond psyllium* seeds was determined as per standardized methods given by Kalyan-sundaram *et al.* (1980) and (1982), respectively.

RESULTS AND DISCUSSION

Effect of sowing methods

Significant increase in seed yield due to line sowing at 30 cm row distance over broadcasting was recorded, which was 20.6 and 22.8 per cent during first and second year, respectively,

Table 1. Effect of sowing methods, nitrogen and weed management on seed yield and quality of *Blond psyllium*

Treatments	Seed yield (q ha ⁻¹)		Husk recovery (%)		Swelling factor (ccg ⁻¹)		Protein content in seed (%)	
	1998-99	1999-2000	Mean	1998-99	1999-2000	Mean	1998-99	1999-2000
Sowing methods								
Broadcasting	8.72	8.00	8.36	28.24	27.05	27.65	11.50	11.26
Line sowing	10.52	9.82	10.17	28.75	27.56	28.16	12.00	11.66
C.D. (P=0.05)	0.40	0.47		NS	NS		NS	NS
Nitrogen (kg ha⁻¹)								
20	8.14	7.42	7.78	29.27	28.07	28.67	12.45	12.10
40	10.33	9.62	9.98	28.88	27.69	28.29	11.80	11.56
60	10.39	9.69	10.04	27.35	26.16	27.76	11.00	10.71
C.D. (P=0.05)	0.49	0.57		1.29	1.07		0.66	0.60
Weed management								
Isoproturon at 0.25 kg ha ⁻¹ + one H.W.	10.19	9.33	9.76	28.57	27.35	27.96	11.81	11.70
Isoproturon at 0.50 kg ha ⁻¹ + one H.W.	11.58	10.72	11.15	28.52	27.30	27.91	11.73	11.59
Isoproturon at 0.75 kg ha ⁻¹ + one H.W.	11.27	10.41	10.84	28.50	27.28	27.89	11.70	11.55
Two manual weeding	11.89	11.06	11.48	28.88	27.67	28.28	11.99	11.65
Unweeded check	3.17	3.05	3.11	28.01	26.94	27.48	11.52	10.80
C.D. (P=0.05)	0.45	0.41		NS	NS		NS	0.53

however, sowing methods failed to affect husk recovery, swelling factor and protein content (Table 1). Increase in seed yield due to line sowing might be the effect of optimum plant population and better growth of plants under this treatment which led to more photosynthesizing area, resulting in production of more assimilates and their better translocation under favourable environment. Increase in seed yield due to line sowing of cumin was also reported by Rajender *et al.* (1999).

Effect of nitrogen

Application of 40 kg N ha⁻¹ produced significantly higher seed yield over 20 kg N ha⁻¹ (Table 1), which was higher by 26.9 and 19.6 percent during 1998-1999 and 1999-2000, respectively. An increase in seed yield due to N application upto 40 kg ha⁻¹ might be attributed to its role in chlorophyll synthesis which directly influence the growth and development of plants and dry matter production of the crop. Kulmi (1998) also reported that application of nitrogen significantly increased seed yield of isabgol.

The husk recovery and swelling factor of blond psyllium seed decreased significantly by raising N level from 40 to 60 kg ha⁻¹ (Table 1). Significant decrease in husk recovery and swelling factor of *Blond psyllium* might be due to the increased concentration of this nutrient in seed which directly affects the synthesis and proportion of carbohydrates in seeds. Reduction in swelling factor and husk recovery with increasing levels of N application have also been reported by Kalyansundaram *et al.* (1982) and Singh (1997).

Protein content in blond psyllium seed improved with the application of nitrogen up to 60 kg ha⁻¹ (Table 1). This appears to be partly due to greater availability of nitrogen on account of increasing N fertilization which in turn increased N content in seed and partly due to accelerating affect of this nutrient on protein synthesis. The results are in conformity with the findings of Singh (1997), who observed an increase in protein content of seed in *Blond psyllium* due to increasing levels of nitrogen.

Weed management

The maximum seed yield of 11.89 q ha⁻¹ during first year and 11.06 q ha⁻¹ during second year was recorded under two manual weedings which was found at par with isoproturon at 0.50 kg ha⁻¹ + one H.W. during both the years (Table 1). The increase in seed yield under weed management treatments was mainly due to reduction in weed population and weed dry matter and thereby providing a favourable environment for crop growth and development of yield attributes. Mehta *et al.* (1985) also observed an increase in yield of *Blond psyllium* due to weed management at early stage. Significant increase in swelling factor during 1999-2000 and protein content in seed during both the years was noticed under different weed management treatments over unweeded check. An increase in quality parameters of blond psyllium in weed management treatments was again the result of reduced weed population and weed dry matter as well as reduced nutrient uptake by weeds. Similar was the finding of Singh (1997) in *Blond psyllium*.

REFERENCES

- Kalyansundaram, N.K., Amin, D.R. and Dala, K.C. 1980. Quality evaluation of blond psyllium seed. Fourteenth sub-committee meeting, Annual Report *rabi* 1980-81. All India Co-ordinated Research Project on Medicinal and Aromatic Plants, Gujarat Agricultural University, Campus : Anand, pp. A23-A26.
- Kalyansundaram, N.K., Patel, P.B. and Dalal, K.C. 1982. Nitrogen need of *Plantago ovata* forsk. in relation to the available nitrogen in soil. *Indian J. Agric. Sci.* 52 (9) : 240-242.
- Karawya, M.S., Balba, S.I. and Afifi, M.S.A. 1971. Investigation on carbohydrate contents of certain mucilaginous plants. *Planta Medica*. 20(1) : 14-23.
- Kulmi, G.S. 1998. Effect of nitrogen levels on growth and yield of isabgol (*Plantago ovata* forsk). Proc. : 12th Workshop of All India Co-ordinated Research Project on Medicinal and Aromatic Plants held at CCS Haryana Agricultural University, Hisar, 27-30th October, 1998, 134-135.

- Mehta, H.M., Trivedi, G.C. and Patel, H.R. 1985. Study the efficacy of herbicides for weed control in isabgol (*Plantago ovata* forsk.). Abstract, ISWS, Weed Sci., Conf., Anand, Gujarat Agricultural University, Anand : 75.
- Rajender, Yadav, S. and Jangir, R.P. 1999. Effect of sowing method, plant population and nitrogen level on yield of cumin (*Cuminum cyminum* L.). *Ann. Arid zone*, 38 (1) : 79-80.
- Singh, I. 1997. Productivity of *Blond psyllium* (*Plantago ovata* forsk.) in relation to weed competition and nitrogen fertilization. Ph. D. Thesis, Rajasthan Agricultural University, Bikaner, Campus, Udaipur.
- Taneja, A., Bhat, C.M., Arora, A. and Kaur, A.P. 1989. Effect of incorporation of isabgol husk in low fibre diet on faecal excretion and serum levels of lipids in adolescent girls. *Eur. J. Nut.*, 43 : 197-202.

RESIDUAL AND DIRECT EFFECTS OF HERBICIDES ON WEEDS AND YIELD OF WHEAT IN RICE-WHEAT CROPPING SYSTEM

K.A. GOPINATH, JITENDRA PANDEY AND B.N. MISHRA

Division of Agronomy
Indian Agricultural Research Institute, New Delhi--110 012

ABSTRACT

A field experiment was conducted to study the residual effect of treatments applied in rice (anilofos at 0.5 kg/ha, pretilachlor at 0.75 kg/ha, at 120 g/ha, hand weeding and weedy check) and direct effect of sulfosulfuron at 25 g/ha, metribuzin at 200 g/ha, hand weeding and weedy check on weeds and yield of wheat in a rice-wheat cropping system. There was severe competition between wheat and the predominant weed species *Phalaris minor*, *Avena ludoviciana* and *Coronopus didymus*. Competition by other weed species was insignificant. The grain yield reduction was 25.4% due to unchecked weed growth. The residual effect of treatments applied in rice was not well pronounced on weed population, weed biomass and yield attributes and yield of wheat in both the years. Metribuzin was the most potent and caused significant decrease in weed population and weed biomass, but had adverse effect on yield attributes and yield of wheat. Hand weeding caused highest increase in yield which was significantly superior to other treatments except sulfosulfuron during 2001-02.

Key words : Herbicides, residual effect, rice, wheat.

Rice-wheat system is the most widely adopted cropping system in India and has become mainstay of cereal production. In recent years, however, this cropping system is showing signs of 'fatigue' due to various reasons. A major constraint is severe weed infestation. Continuous cropping of morphologically changed varieties of these two crops and shifts in sowing paradigm have increased the incidence of weeds in rice-wheat zones causing heavy yield losses. The literature on use of herbicides in rice and wheat indicated many selective herbicides for effective weed control (Gogoi, 1997 and Pandey *et al.* 2002). However, very little information is available on residual effect of herbicides applied in rice on succeeding wheat crop. It is necessary to have the knowledge of residual effect of herbicides applied in rice on succeeding wheat as well as direct effect of herbicides applied in wheat on weed control and yield of wheat to use them safely and effectively in a rice-wheat cropping system. Hence, the present study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted during 2000-01 and 2001-02 at the Indian Agricultural Research Institute, New Delhi. The soil of the experimental field was sandy clay loam with pH 8.0 to 8.1, medium in organic carbon (0.52 to 0.54%), available P (16.8 to 17.1 kg/ha) and available K (215 to 216 kg/ha). The experiment consisting 20 treatment combinations was laid out in an extended group design (rectangular design). The experiment with rice (*khari*) was conducted involving three herbicides anilofos at 0.5 kg/ha, pretilachlor at 0.75 kg/ha and flufenacet at 120 g/ha along with hand weeding 20 and 40 days after transplanting (DAT) and weedy check. Two herbicides sulfosulfuron at 25 g/ha and metribuzin at 200 g/ha along with hand weeding 30 and 45 days after sowing (DAS) and weedy check were imposed in wheat.

One month old seedlings of rice variety 'Pusa 44' were transplanted on 19 and 17 July in 2000 and 2001, respectively at a spacing of 20 cm × 10

cm. Wheat variety HD 2285 was sown on 1 and 6 December in 2000-01 and 2001-02, respectively, in lines of 22 cm apart using 100 kg seed/ha. A fertilizer dose of 100 kg N for rice and 120 kg N for wheat and a uniform dose of 60 kg P_2O_5 and 40 kg K_2O /ha was used for each crop. Full quantity of P and K and half of nitrogen was applied as basal in both crops. Remaining half of nitrogen was applied 40 days after transplanting (DAT) in rice and in two equal splits 30 and 60 days after sowing (DAS) in wheat. Herbicides were applied 3 DAT in rice and 35 DAS in wheat. All the herbicides except flufenacet were applied using a volume spray of 600 litres/ha with the help of knapsack sprayer fitted with flat-fan nozzle. Flufenacet was mixed with sand at 50 kg/ha and uniformly broadcasted. Two hand weedings were done 20 and 40 DAT in rice and 30 and 45 DAS in wheat. Data on weed population and weed dry matter accumulation were recorded at 60 and 90 days, respectively, in rice and wheat and subjected to square-root transformation ($\sqrt{x+0.5}$) before statistical analysis.

RESULTS AND DISCUSSION

Weed flora

Weed species in the experimental plot consisted of a mixed population of grass (72.5%) and broadleaf (27.5%) weeds. *Phalaris minor* (27.1%), *Avena ludoviciana* (16.8%), *Coronopus didymus* (11.3%), *Poa annua* (6.9%) and *Melilotus india* (6.8%) were the dominant weed species which severely competed with the wheat crop. Besides these, *Chenopodium murale*, *Rumex* sp., *Fumaria parviflora*, *Colvolvulus arvensis*, *Anagallis arvensis* and *Cyperus rotundus* also competed, but the competition by these species was insignificant as their populations were very small.

Effect on weeds

The residual effect of treatments (applied to rice) was not well pronounced on weed population and dry matter accumulation by weeds in succeeding wheat except on broadleaf weeds in 2000-01. Significantly lower population was recorded in hand weeding compared to weedy check (Table 1). Pandey (2002) also did not found any effect of herbicides applied to rice

on weeds in succeeding wheat. The direct effect of weed control treatments was well marked on weed population and dry matter accumulation by weeds in both the years. Metribuzin was the most potent and caused significant decrease in the population of both grass and broadleaf weeds and weed dry weight. It killed almost all the broadleaf weeds and completely ceased the growth of both *Phalaris minor* and *Avena ludoviciana*. The latter first turned yellow and gradually died after about 20 days. Similar was the finding of Pandey *et al.* (2002). Hand weeding was the next most effective treatment against weeds. Sulfosulfuron gave good control of grass weeds but was ineffective against broadleaf weeds.

Effect on crop

The residual effect of treatments (applied to rice) was no noticeable on any yield attributes and yield of succeeding wheat (Table 2). Nandal and Singh (1994) and Pandey (2002) also reported similar results. All the weed control treatments applied to wheat brought about significant increase in yield attributes and yield of wheat in both the years. Hand weeding registered higher values for all yield attributes and proved insignificantly superior to other treatments except sulfosulfuron in 2001-02 in respect of effective tillers. Metribuzin had adverse effect on effective tillers in both years. However, it recorded significantly higher grain weight/ear in both years and 1000-grain weight in 2000-01 compared to sulfosulfuron.

The grain reduction was 25.4% due to unchecked weed growth. Hand weeding caused 34.1% increase in grain yield and proved significantly superior to all other treatments except sulfosulfuron in 2001-02 (Table 2). This may be attributed to drastic decrease in weed population and dry matter accumulation by weeds, thereby better crop growth, increased productive tillers and yield attributes. Similar results were earlier reported by Pandey (2002). Lower yield of metribuzin may be assigned to its determinental effect on crop growth and effective tillers, despite excellent control to dominant weeds. Pandey *et al.* (2002) also reported similar results.

Table 1. Residual and direct effect of treatments on weed population per m² in wheat (60 DAS)

Treatment	Grass weeds		Broadleaf weeds		Total weeds		Weed dry weight (g/m ²)	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Residual effect								
Anilofos 0.5 kg/ha	11.2 (204.0)	11.6 (198.8)	8.3 (100.4)	7.7 (84.4)	14.2 (304.4)	14.1 (283.2)	5.17 (32.56)	4.74 (27.76)
Pretilachlor 0.75 kg/ha	11.0 (202.0)	11.5 (197.6)	8.3 (101.6)	7.9 (84.8)	14.0 (303.6)	14.1 (282.2)	5.30 (33.72)	4.67 (27.40)
Flufenacet 120 g/ha	10.9 (192.4)	11.6 (202.4)	8.5 (102.0)	8.0 (89.6)	14.1 (294.4)	14.2 (292.0)	5.26 (34.12)	4.59 (26.44)
Hand weeding	10.9 (196.8)	11.6 (198.4)	8.0 (96.8)	7.8 (84.4)	13.7 (293.6)	14.1 (282.8)	5.19 (32.84)	4.51 (26.40)
Weedy check	11.3 (203.2)	11.7 (200.4)	8.7 (103.2)	8.0 (87.6)	14.4 (306.4)	14.3 (288.0)	5.28 (33.56)	4.80 (28.08)
C.D. (P=0.05)	NS	NS	0.60	NS	NS	NS	NS	NS
Direct effect								
Sulfosulfuron 25 g/ha	6.4 (39.2)	7.3 (52.8)	9.7 (92.8)	8.9 (78.4)	11.6 (132.0)	11.5 (131.2)	4.75 (21.68)	4.12 (16.20)
Metribuzin 200 g/ha	3.9 (16.4)	4.4 (21.2)	1.5 (2.0)	1.6 (2.8)	4.3 (18.4)	4.7 (24.0)	2.72 (7.16)	2.29 (5.16)
Hand weeding	7.9 (64.0)	9.2 (82.4)	6.0 (36.0)	6.0 (34.4)	9.9 (100.0)	11.0 (116.8)	4.09 (16.16)	3.63 (12.76)
Weedy check	25.9 (678.4)	25.3 (641.6)	16.3 (272.0)	15.0 (228.0)	30.6 (950.4)	29.4 (869.6)	9.39 (88.48)	8.59 (74.72)
C.D. (P=0.05)	0.92	0.66	0.66	0.60	1.06	0.63	0.23	0.43

Figures in parentheses indicate original values.

Table 2. Residual and direct effect of treatments on yield attributes and yield of wheat

Treatment	Effective tillers /mrl*		Grain weight /ear(g)		1000-grain weight (g)		Grain yield (q/ha)	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Residual effect								
Anilofos 0.5 kg/ha	93.6	97.5	2.08	2.10	40.08	40.58	47.39	48.79
Pretilachlor 0.75 kg/ha	94.3	97.3	2.06	2.05	40.36	40.63	47.99	49.26
Flufenacet 120 g/ha	93.7	97.2	2.02	2.08	40.28	40.70	47.70	48.63
Hand weeding	94.4	97.7	2.08	2.08	40.37	40.78	48.20	49.26
Weedy check	93.2	96.9	2.03	2.04	40.21	40.56	47.58	48.54
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Direct effect								
Sulfosulfuron 25 g/ha	99.5	103.5	2.00	2.04	40.02	40.39	50.10	52.02
Metribuzin 200 g/ha	87.8	94.1	2.12	2.13	40.58	41.03	45.77	47.45
Hand weeding	107.1	108.3	2.26	2.24	41.56	41.74	54.75	54.71
Weedy check	80.8	83.6	1.85	1.89	38.89	39.27	40.34	41.47
C.D. (P=0.05)	4.56	5.25	0.11	0.08	0.69	0.66	2.81	3.30

mrl* : meter row-length.

REFERENCES

- Gogoi, A.K. 1997. *Ann. agric. Res.*, **18** (4) : 510-514.
- Nandal, D.P. and Singh, C.M. 1994. *Indian J. Agron.*, **39**(4) : 517-521.
- Pandey, J. 2002. *Extended Summaries '2nd International Agronomy Congress'*, 26-30 November, 2002, New Delhi. **2** : 1166-1167.
- Pandey, J., Gopinath, K.A. and Verma, A.K. 2002. *Acta Agronomica Hungarica*, **50**(4) : 441-445.

INFLUENCE OF MOISTURE CONSERVATION AND NUTRIENT MANAGEMENT ON YIELD, WATER USE EFFICIENCY AND NUTRIENT UPTAKE OF PEARLMILLET (*Pennisetum glaucum*)

NARENDRA KUMAR AND R.C. GAUTAM

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110 012

ABSTRACT

Effect of moisture conservation and nutrient management practices (FYM, biofertilizers and fertilizer N) on yield, WUE, and nutrient uptake of pearl millet were studied under rainfed farming for two years (2001-2002). Pearl millet yield was strongly dependent on the distribution of rainfall, particularly at the reproductive phase. The yield was higher under the treatment of mulching and for treatment receiving FYM @ 5 t/ha + biofertilizer (*Azospirillum* + PSB) + 90 kg N/ha in good rainfall as well as drought years (2001 and 2002, respectively). Mulching practices also increased the WUE as well as NPK uptake over uniform row. Higher WUE and NPK uptake was observed under combined application of FYM + biofertilizer and fertilizer N.

Key words : Moisture conservation, nutrient, yield, pearl millet.

In arid and semi-arid regions of India, rainfall is low and erratic. Therefore, crops often experience drought at various stages of growth and as a result, yields are generally low (Beggs and Turner, 1976). Moisture conservation practices as mulching brought about marked increase in the productivity of pearl millet due to increased period of moisture availability (Pandey *et al.* 1988).

The adverse effects of drought on crop yields are further accentuated due to the poor fertility status of soils. Improvement in the fertility status of soil is considered an important strategy of drought management in rainfed areas, as crop grown under better fertility conditions are known to withstand drought for a longer duration and reported to higher yield (Lahiri, 1993). But, with unreliable rainfall, good grain yields are response to fertilizer is never certain. Therefore, depending on chemical fertilizer and alone may not provide a viable economic option. Further a major part of N applied is lost as NH_3 volatilization (Aggarwal *et al.* 1989). Therefore, to maintain soil productivity on a sustainable basis, an integrated nutrient management approach, using organic, inorganic and biological sources of nutrient should be adopted. The use

of organic manure and biofertilizer must be given prime importance, and fertilizer use should be limited to balance the nutrient (requirement of the crops (Aggarwal and Venkateswarlu, 1989).

Therefore, an experiment was conducted for two years to see the effects of moisture conservation and integrated nutrient management on yield and nutrient uptake of pearl millet (*Pennisetum glaucum* (L.) R.Br. Emend. Stuntz).

MATERIALS AND METHODS

An experiment was conducted during *kharif* 2001 and 2002 at the Indian Agricultural Research Institute, New Delhi. Treatments comprised of moisture conservation practices (uniform row, paired row + legume as mulch and paired row + crop residue as mulch) in main plots and nutrient management practices (control, FYM in combination with 30, 60 and 90 kg N/ha, FYM + biofertilizer (*Azospirillum* + PSB) and its combination with 30, 60 and 90 kg N/ha and recommended dose of N) in sub-plots under split-plot design. The treatments were replicated three times. The pearl millet hybrid Pusa-605 was used for experiment. Urd (Var. T-9) was sown in between paired row as per main plot

Table 1. Effect of moisture conservation and nutrient management practices on yield and water use efficiency of pearl millet

Treatments	Grain yield (q/ha)		Stover yield (q/ha)		Water use efficiency (kg grain/ha/mm)	
	2001	2002	2001	2002	2001	2002
Moisture conservation practices						
Uniform row	26.67	20.73	90.21	78.51	6.66	7.38
PR + legume as mulch	29.23	24.44	99.21	81.69	8.01	9.28
PR + crop residue as mulch	28.59	24.72	96.66	81.61	7.82	9.34
SEm±	0.24	0.30	0.69	1.78	-	-
C.D (P=0.05)	0.93	1.19	2.70	NS	-	-
Nutrient management practices						
Control	18.24	14.60	67.83	60.36	4.90	5.30
FYM @ 5 t/ha	22.98	17.45	77.77	65.12	6.21	6.44
FYM @ 5 t/ha + 30 kg N/ha	29.17	24.37	99.37	84.97	7.79	9.14
FYM @ 5 t/ha + 60 kg N/ha	30.92	25.89	104.19	83.16	8.14	9.59
FYM @ 5 t/ha + 90 kg N/ha	31.19	26.05	105.43	87.28	8.15	9.54
FYM @ 5 t/ha + BF	23.22	18.64	80.03	67.93	6.37	6.94
FYM @ 5 t/ha + BF + 30 kg N/ha	30.77	26.95	101.46	86.55	8.31	10.29
FYM @ 5 t/ha + BF + 60 kg N/ha	32.65	27.19	109.86	90.30	8.75	10.24
FYM @ 5 t/ha + BF + 90 kg N/ha	32.77	27.33	110.96	93.53	8.71	10.15
Recommended dose (60 kg N/ha)	27.07	24.52	95.48	86.80	7.18	8.99
SEm±	1.17	0.88	4.30	3.78	-	-
C.D. (P=0.05)	3.31	2.49	12.20	10.73	-	-

PR = Paired row; BF = Biofertilizer (*Azospirillum* + phosphate solubilizing bacteria).

Table 2. Effect of moisture conservation and nutrient management practices on nutrient uptake of pearl millet

Treatments	N-uptake (kg/ha)		P-uptake (kg/ha)		K-uptake (kg/ha)	
	2001	2002	2001	2002	2001	2002
Moisture conservation practices						
Uniform row	113.54	90.77	36.84	31.19	134.60	114.31
PR + legume as mulch	131.57	104.20	43.43	35.27	158.62	130.84
PR + crop residue as mulch	127.95	103.32	41.89	35.38	152.66	130.03
SEm±	0.96	1.78	0.61	0.68	2.12	3.18
C.D. (P=0.05)	3.76	4.22	2.38	2.68	8.31	12.46
Nutrient management practices						
Control	81.42	65.13	25.90	22.68	102.20	89.32
FYM @ 5 t/ha	98.59	75.55	32.49	26.16	119.47	98.90
FYM @ 5 t/ha + 30 kg N/ha	128.92	103.34	42.28	35.86	153.81	130.91
FYM @ 5 t/ha + 60 kg N/ha	130.10	108.43	45.02	36.43	162.53	129.68
FYM @ 5 t/ha + 90 kg N/ha	139.90	112.35	45.64	37.64	165.40	136.24
FYM @ 5 t/ha + BF	101.82	81.46	36.81	27.54	123.87	103.44
FYM @ 5 t/ha + BF + 30 kg N/ha	135.46	113.18	43.41	37.92	159.70	137.55
FYM @ 5 t/ha + BF + 60 kg N/ha	146.30	117.20	46.94	39.06	173.20	143.82
FYM @ 5 t/ha + BF + 90 kg N/ha	147.70	120.18	47.50	40.01	175.20	148.53
Recommended dose (60 kg N/ha)	123.74	102.96	41.27	35.57	146.90	132.63
SEm±	5.41	4.22	1.88	1.47	6.70	5.73
C.D. (P=0.05)	15.34	15.34	5.34	4.17	18.99	16.25

PR = Paired row; BF = Biofertilizer (*Azospirillum* + phosphate solubilizing bacteria).

treatments and it was incorporated to upper soil layer at about 40 DAS. During same period, wheat crop residue was used for mulching.

RESULTS AND DISCUSSION

A perusal of data (Table 1) revealed that during both the years of experimentation, grain yield of pearl millet increased significantly due to mulching. However, significant increase in stover yield was recorded only in 2001. But the mulching practices were statistically at par, but significantly superior over uniform row system. Grain yield of pearl millet indicated about 10 and 19 per cent increase over uniform row with mulching practices during 2001 and 2002, respectively. Dahiya and Singh (1977) reported 9.7 per cent increase in grain yield over control due to straw mulching.

Effect of integrated nutrient management was also found significant on grain and stover yield during both the years. The treatment of FYM, biofertilizer and different levels of fertilizer N recorded at par results, however, maximum grain yield was recorded with FYM @ 5 t/ha + biofertilizer + 90 kg N/ha. The average increase in grain yield over control was about 83 per cent and over recommended dose of N was about 17 per cent. However, stover yield increased up to 58 per cent over control. Gupta *et al.* (1983) reported 30 per cent increase in grain

and stover yield of pearl millet due to integrated application of FYM and fertilizer N.

Moisture conservation practices brought improvement in WUE by pearl millet. The improvement in WUE was about 20 and 26 per cent during 2001 and 2002, respectively. The combination of FYM, biofertilizer and fertilizer N also improved the WUE by pearl millet. The improvement was recorded up to 78 per cent during 2001 and 94 per cent during 2002 with integrated nutrient management over control. The similar results were reported by Kaushik and Lal (1997) with mulching and Ciesse (1988) with FYM.

Mulching increased the grain and stover yield and NPK content in grain and stover. This resulted in increased NPK uptake by pearl millet due to mulching. The highest value of NPK uptake was obtained with paired row + legume as mulch. NPK uptake also increased with integrated application of FYM, biofertilizer and fertilizer N. The highest NPK uptake by pearl millet was recorded with FYM @ 5 t/ha + biofertilizer + 90 kg N/ha. NPK uptake increased with FYM and biofertilizer application and also with increased level of N-fertilization (Table 2). Ciesse (1988) recorded increased NPK uptake with FYM application, Bagga and Tomar (1983) with increased level of fertilizer N.

REFERENCES

- Aggarwal, R.K. and Venkateswarlu, J. 1989. Long term effect of manures and fertilizers on important cropping systems of arid region. *Fert. News*, **34** : 67-70.
- Aggarwal, R.K., Raina, P. and Praveen Kumar. 1989. Ammonia volatilization from urea and their possible management for increasing nitrogen use efficiency in an arid region. *J. Arid. Env.*, **13** : 163-168.
- Bagga, R.K. and Tomar, P.S. 1983. Effect of dates of nursery seeding, age of seedling and nitrogen levels on late sown hybrid pearl millet. *Indian J. Agric. Sci.*, **53**(2) : 129-133.
- Begg, J.E. and Turner, N.C. 1976. Crop water deficits. *Adv. Agron.*, **28** : 161-217.
- Ciesse, L. 1988. Effect of organic matter application on millet and groundnut on a degraded soil in North Senegal. II. Plant development and nutrient uptake. *Agronomic*, **8**(5) : 411-417.
- Dahiya, D.R. and Singh, K. 1977. Effect of nitrogen doses and its time and method of application on pearl millet with and without mulch in dry farming condition. *Indian J. Agron.*, **22**(1) : 35-40.
- Gupta, J.P., Aggarwal, R.K., Gupta, G.N. and Kaul, P. 1983. Effect of continuous application of farmyard manure and urea on soil properties and the production of pearl millet in western Rajasthan. *Indian J. agric. Sci.*, **53** (1) : 53-56.
- Kaushik, S.K. and Lal, K. 1997. Relative efficiency of mulches and Antitranspirants on productivity

- and water use efficiency of rainfed pearl millet (*Pennisetum glaucum* L.). *Indian J. Agron.*, **29**(1) : 104-106.
- Lahiri, A.N. 1993. Drought and its effect on crop productivity. In "Desertification and its control in Thar, Sahara and Sahel Regions" (Eds. A.K. Sen and A. Kar). Scientific Publishers, Jodhpur, pp. 169-186.
- Pandey, S.K., Kaushik, S.K. and Gautam, R.C. 1988. Response of rainfed pearl millet (*Pennisetum glaucum* L.) to plant density and moisture conservation. *Indian J. agric. Sci.*, **58** : 517-520.

PERFORMANCE OF WHEAT (*TRITICUM AESTIVUM*) AS INFLUENCED BY N-MANAGEMENT PRACTICES IN PRECEDING CROP OF COTTON (*GOSSYPIUM HIRSUTUM* L.)

ANUP DAS, MANGAL PRASAD AND R.C. GAUTAM

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110 012

ABSTRACT

Field experiments were conducted to study the residual effect of N management practices adopted in cotton (*Gossypium hirsutum* L.) on growth, yield and quality of succeeding wheat (*Triticum aestivum* L.) crop under irrigated conditions. Highest residual effect in terms of improved growth and yield attributing characters were observed with combined application of 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹ + *Azotobacter*. Different doses of fertilizer N alone failed to show any substantial residual effect on the performance of succeeding wheat crop. Among the three N sources i.e., fertilizer N, FYM and *Azotobacter*, the application of FYM @ 12 t ha⁻¹ to preceding crop of cotton recorded the highest growth, yield attributes, protein content and N uptake of succeeding wheat crop.

Key words : Residual effect, farm yard manure, *Azotobacter*, fertilizer nitrogen, wheat.

The existing system of fertilizer management is based on the nutrient requirement of individual crop ignoring the carry over effect of the manure or fertilizer applied to the preceding crop. Indications are available of saving some fertilizers, if fertilizer management is done for the cropping system. Residual effect may be more pronounced for organic manures like farm yard manure as only a part of its nutrient content is available to the first crop. Organic sources of nutrients applied to preceding crop benefits the succeeding crop to a great extent (Hegde, 1998) and the system productivity become sustainable through integrated use of organic and inorganic sources of nutrients (Singh and Yadav, 1992). However, a very few literature are available on this aspect and the present study was an attempt in this direction.

MATERIALS AND METHODS

Field experiments was conducted at IARI, New Delhi during 2001-02 and 2002-03 under irrigated conditions. The trial was laid out in randomized block design with three replications. The eleven treatments on cotton comprised of control, 30 kg N ha⁻¹, 60 kg N ha⁻¹, *Azotobacter* (M₄), *Azotobacter* (W₅), FYM @ 12 t ha⁻¹, 30 kg N

ha⁻¹ + *Azotobacter* (M₄), 30 kg N ha⁻¹ + *Azotobacter* (W₅), 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹, 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹ + *Azotobacter* (M₄) and 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹ + *Azotobacter* (W₅). Soil of the experimental field was sandy loam in texture, low in available nitrogen and medium in available phosphorus and potassium. The pH and organic carbon content of the soil was 7.9 and 0.41% respectively. Cotton cultivar 'Pusa 8-6' and wheat cultivar 'HD 2285' were used as experimental materials. *Azotobacter* strains (M₄ and W₅) were obtained from the Microbiology Division, IARI, New Delhi and inoculated to cotton. Rest of the practices for both the crops were as per normal recommendations.

RESULTS AND DISCUSSION

Growth attributes of wheat

Plant height of wheat was not influenced significantly by the residual effect of N management. However, there was significant effect on the dry matter production of wheat. All the treatments that include FYM as a component, showed comparatively higher values of growth attributes of wheat (Table 1). Combined application of 30 kg N ha⁻¹ + FYM @

Table 1. Growth and yield attributes of wheat as influenced by N management practices in preceding crop of cotton

Residual effect from cotton	Plant height (cm)		Dry matter production (g m ⁻²)		Ears m ⁻²		Grains ear ⁻¹		Test weight (g)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Control	86.9	88.5	1095	1110	292.0	292.0	39.0	39.1	40.6	40.8
30 kg N ha ⁻¹	87.4	88.9	1102	1132	295.0	296.0	39.2	39.2	40.7	40.8
60 kg N ha ⁻¹	87.9	89.4	1109	1145	297.0	302.0	39.3	39.4	40.7	40.9
Az. M ₄	87.2	88.8	1103	1130	295.0	297.0	39.1	39.2	40.6	40.8
Az. W ₅	87.0	88.7	1100	1126	294.0	296.0	39.1	39.2	40.6	40.8
FYM @ 12 t ha ⁻¹	89.0	90.7	1155	1182	302.0	305.0	40.5	41.3	40.9	41.1
30 kg N ha ⁻¹ + Az. M ₄	87.7	89.3	1116	1142	297.0	301.0	39.4	39.4	40.7	40.9
30 kg N ha ⁻¹ + Az. W ₅	87.7	89.2	1107	1135	297.0	300.0	39.2	39.3	40.7	40.8
30 kg N ha ⁻¹ + FYM	89.3	91.1	1167	1206	302.0	309.0	41.0	41.5	40.9	41.2
30 kg N ha ⁻¹ + FYM + Az. M ₄	89.9	91.5	1174	1215	307.0	313.0	41.1	41.6	41.1	41.2
30 kg N ha ⁻¹ + FYM + Az. W ₅	89.6	91.3	1168	1212	304.0	310.0	41.1	41.6	41.0	41.3
C.D. (P=0.05)	NS	NS	70	93.0	NS	NS	1.51	1.82	NS	NS

Az. = Azotobacter, FYM @ 12 t ha⁻¹.

Table 2. Nitrogen uptake, yield and quality of wheat as influenced by N management practices in preceding crop of cotton

Residual effect from cotton	2001-02		2002-03		2001-02		2002-03		2001-02		2002-03		2001-02		2002-03		2001-02		2002-03	
	N uptake (kg ha ⁻¹)		Grain		Straw		Grain yield (q ha ⁻¹)		Straw yield (q ha ⁻¹)		Harvest index (%)		Protein content in grain (%)							
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	76.6	29.9	78.4	28.3	42.2	43.1	62.6	63.3	40.19	40.49	10.83	10.86								
30 kg N ha ⁻¹	78.0	28.5	80.2	28.8	42.7	44.0	83.5	64.2	40.17	40.58	10.90	10.88								
60 kg N ha ⁻¹	79.4	29.1	81.6	29.4	43.4	44.8	64.7	65.1	40.14	40.61	10.92	10.91								
Az. M ₄	77.9	28.3	79.8	28.6	42.7	43.8	63.3	63.7	40.25	40.74	10.89	10.88								
Az. W ₅	77.4	28.2	79.7	28.6	42.7	43.8	63.3	63.7	40.17	40.70	10.88	10.87								
FYM @ 12 t ha ⁻¹	81.7	29.8	85.5	30.8	54.5	46.5	65.7	67.4	40.38	40.78	10.95	10.98								
30 kg N ha ⁻¹ + Az. M ₄	79.0	28.9	81.0	29.4	43.2	44.4	63.7	64.9	40.41	40.65	10.92	10.89								
30 kg N ha ⁻¹ + Az. W ₅	78.9	28.7	80.6	29.2	43.2	44.2	64.0	64.6	40.29	40.57	10.90	10.88								
30 kg N ha ⁻¹ + FYM	83.3	30.3	86.5	31.1	45.2	47.0	66.6	68.0	40.41	40.82	10.97	10.99								
30 kg N ha ⁻¹ + FYM + Az. M ₄	83.9	30.8	87.8	31.5	45.8	47.6	67.2	68.7	40.42	40.91	10.98	11.01								
30 kg N ha ⁻¹ + FYM + Az. W ₅	83.7	30.5	87.3	31.4	45.5	47.4	66.9	68.4	40.44	40.93	10.98	11.00								
C.D. (P=0.05)	6.70	NS	6.40	NS	2.9	3.2	NS	4.8	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Az. = Azotobacter, FYM @ 12 t ha⁻¹.

12 t ha⁻¹ + *Azotobacter* (M₄) to preceding cotton resulted in the higher values of growth attributes compared to other treatments of wheat.

Yield attributes

N-management practices adopted to preceding crop of cotton caused notable variation in the yield attributes of wheat (Table 1). Among the yield attributes, only the number of grains per ear varied significantly. Highest values of all the yield attributes were recorded with combined application of organic and inorganic sources of nitrogen [i.e., 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹ + *Azotobacter* (M₄ or W₅)] to cotton. Next best combination that gave higher values of yield attributes was 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹. It is clear from the data that residual effect of FYM either alone or in combination with fertilizer N and *Azotobacter* was most pronounced on succeeding wheat over individual application of fertilizer N or *Azotobacter*. Similar results were obtained by Raghuwanshi and Umat (1994).

Grain yield, straw yield and harvest index of wheat

Nitrogen management practices in preceding cotton showed significant effect on grain yield of wheat during both the years. Straw yield was significant only in the second year. Significantly higher grain yield was observed only when FYM @ 12 t ha⁻¹ was applied either only with 30 kg N ha⁻¹ or with combination of 30 kg N ha⁻¹ + *Azotobacter* (M₄ or W₅). All the three combinations were at par. Rest of the treatments failed to produce any significant

effect on grain yield and were at par. Straw yield followed the similar trend of grain yield. Pronounced residual effect of organic manures especially when applied with fertilizer N was also indicated by Singh *et al.* (1981) and Ram Prakash and Prasad (2000). This could be ascribed to higher residual nutrient availability and subsequent improved uptake pattern that might have resulted in higher dry matter production, yield attributes and yield. Harvest index of wheat did not alter significantly with N management practices in preceding cotton.

N uptake and protein content of wheat

Combined application of 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹ + *Azotobacter* (M₄ or W₅) recorded significantly higher N uptake of grain compared to control (Table 2). Next best treatment combination that gave higher N uptake was 30 kg N ha⁻¹ + FYM @ 12 t ha⁻¹. No significant effect on N removal by wheat straw was observed during both the years. *Azotobacter* (M₄ or W₅) either alone or in combination with fertilizer N could not produce significant effect on N uptake of wheat. Singh *et al.* (1981) also found substantial improvement in N uptake of succeeding wheat due to residual effect of FYM @ 12 t ha⁻¹ applied to preceding crop of bajra. Protein content of wheat did not alter significantly due to N management practices adopted in preceding cotton. However, data revealed the positive residual effect of organic manure especially when fertilizer N was also applied.

REFERENCES

- Hegde, D.M. 1998. *Indian J. Agron.*, **43** (2) : 189-198.
- Raghuwanshi, R.K.S. and Umat, R. 1994. *Indian J. Agron.*, **39** (2) : 193-197.
- Ram Prakash and Prasad, M. 2000. *Indian J. Agron.*, **45** (2) : 263-268.
- Singh, B.P., Chahal, R.S. and Singh, M. 1981. *Fert. News*, **26** (8) : 16-19.
- Singh, G.B. and Yadav, D.V. 1992. *Fert. News*, **37** (4) : 15-22.

EFFECT OF TILLAGE PRACTICES AND PLANT POPULATION ON PERFORMANCE OF SUNFLOWER

B.N. REDDY AND S.N. SUDHAKARA BABU

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030

ABSTRACT

Field experiments were conducted to study the productivity of sunflower under the influence of tillage and plant density. Deviation from conventional tillage affected plant stand at all levels of plant population. Highest yield of sunflower was obtained in reduced tillage (cultivation once with tractor drawn followed by harrowing twice by bullock drawn harrow). Higher plant stand, plant height, diameter of the capitulum and test weight was recorded in conventional and reduced tillage treatments and were significantly higher over minimum tillage. Recommended plant population resulted in highest seed yield compared to 75 and 200% of recommended population. The oil yield was also maximum under reduced tillage practice with recommended plant population.

Key words : Tillage, plant population, sunflower, rice fallows, vertisol.

The growing limitation of water resources in irrigation command areas, tank fed and well irrigated areas demands for the cultivation of irrigated dry crops in rainy season rice fallows. Pulses and oilseeds hold promise in such situations by virtue of their low water requirement. Sunflower (*Helianthus annuus* L.) has emerged as a potential oilseed crop after rice. The crop has highest per day productivity of seed and oil besides low water requirement. The higher production efficiency and net returns from rice-sunflower sequence was reported in Andhra Pradesh (Krishna and Ananda Reddy, 1997), Orissa (Shah *et al.* 1998) and West Bengal (Sarkar *et al.* 1995). The soil conditions after puddle rice pose limitation for growing aerable crops and thus yield levels of crops following rice are generally low as compared to the normal yield of these crops (Reddy and Reddy (1979). The main problems for crops after puddle rice are low plant establishment due to bigger clods formed by paddy stubbles, restricted root growth and poor aeration due to hard pan in sub soil and low nutrient use efficiency due to adverse physical, chemical and biological environment in the rhizosphere. In order to determine the optimum tillage requirement with reduced energy and efforts and to reduce the

high cost of sunflower seed, further to trade off between tillage practices and seed rate, the present investigation was carried out for achieving optimum tillage and plant stand for optimal yield of sunflower.

MATERIALS AND METHODS

Field experiments were conducted on medium deep black clay soil of Agricultural Research Station, Gangavati, Karnataka during summer season of 1996 and 1997 where in rainy season, row planted puddled rice was the previous crop. Sunflower hybrid KBSH-1 was raised under three tillage practices (minimum tillage, reduced tillage and conventional tillage) in main plots. Four plant populations (75% recommended : 70 × 30 cm = 44,447 plants/ha; recommended : 60×30 cm = 55,555 plants/ha; 125% recommended; 40×30 cm = 74,074 plants/ha and 200% recommended : 45×20 cm = 1,11,111 plants/ha) were assigned to sub plots in split plot design with three replications. The soil of the experimental field was high in available N (organic carbon = 0.56%), medium in available phosphorus (13.5 kg P₂O₅/ha) and available potassium (291 kg K/ha) with a pH of 7.60. Conventional tillage comprised of working twice with tractor drawn cultivator (criss-cross)

followed by harrowing twice (criss-cross), reduced tillage consisted of working once with tractor drawn cultivator (criss-cross) followed by twice harrowing (criss-cross) and in minimum tillage, the surface biomass of weeds and paddy stubbles were suppressed by using herbicide paraquat and after a week's time, with a pre-sowing light irrigation, furrows were opened in between rows of paddy stubbles at 60 cm and sowing was done by hand dibbling as per the sub plot treatments during last week of January. The crop received two irrigations and the source of irrigation was through Tunga Bhadra left bank canal. The weather during the growing season was normal.

RESULTS AND DISCUSSION

Effect of tillage

During 1996-1997, tillage treatment markedly influenced the growth and yield of sunflower (Tables 1 and 2). All the attributes viz., plant population, plant height, head diameter and test weight recorded lower values in minimum tillage. These values were higher in reduced tillage which recorded significantly higher seed yield over conventional and minimum tillages. The magnitude of yield increase in reduced tillage was to the extent of 130% over minimum tillage. The oil content and oil yield was similar in conventional and reduced tillage but were significantly higher compared to minimum tillage. During 1997-98, tillage practices significantly influenced the seed yield and oil yield. The seed yield was the highest with conventional tillage (424 kg/ha) followed by reduced tillage (390 kg/ha), which were almost similar. Significantly lower yield (320 kg/ha) was recorded with minimum tillage. Similar to seed yield, the oil yield was also significantly higher with conventional tillage (154 kg/ha) followed by reduced tillage (150 kg/ha). The least was with minimum tillage (119 kg/ha). The superior performance of sunflower in conventional and reduced tillage over minimum tillage can be attributed to more number of plants at harvest and increased head diameter.

The results of pooled data of two years revealed that the performance of sunflower was superior with conventional and reduced tillage

practices which recorded similar seed yields but was significantly superior to minimum tillage.

On an average, conventional and reduced tillage registered an increase in seed yield to the magnitude of 66.9% and 70.4%, respectively over minimum tillage. The beneficial effect of tillage operations was evident in vertisols. In minimum tillage, uneven and low plant stand coupled with higher weed intensity resulted in the poor performance of the crop. Leaf area index was also significantly lower in minimum tillage compared to conventional and reduced tillage. The better performance of sunflower by practicing tillage operation through ploughing followed by rotovators is reported by Pratibha *et al.* (1994).

Effect of plant population

During 1996-97, the recommended plant population recorded maximum yield (558 kg/ha). This was due to higher head diameter and increased test weight besides optimum plant density. Reduction in head size at 200% of recommended population and lower test weight coupled with reduction in expected plant population has caused for lower yields. Similar to seed yield, the recommended plant population has also resulted in higher oil yield.

During 1997-98, among the plant population levels, the number of plants at harvest were significantly higher at 200% of recommended population which recorded taller plants while stem girth was higher with 75% of recommended population which can be attributed to optimum competition for the growth. The seed yield was significantly higher (470 kg/ha) with recommended population, followed by 125% of recommended population. The lowest yield (325 kg/ha) was recorded with 200% of recommended plant population. Oil yield was significantly higher (174 kg/ha) with recommended plant population.

The pooled data of two years revealed that higher yield can be realized when sunflower was grown at its recommended plant population i.e., 55,555 plant/ha. Decreased per plant productivity at 200% of recommended population and reduced number of plants at 75%

Table 1. Effect of tillage and plant population on growth and yield attributes of sunflower in rice fallow vertisols

Treatment	Final plant population ('000/ha)			Plant height (cm)			Head diameter (cm)			1000-seed weight (g)		
	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled
Tillage												
Conventional	76.7	58.3	67.5	112	125	119	7.97	7.19	7.60	30.0	28.0	29.0
Reduced	71.2	59.8	65.5	117	119	118	8.81	7.00	7.90	29.8	29.2	30.0
Minimum	47.0	50.5	49.0	88	117	103	7.16	7.14	7.20	25.5	30.7	29.0
SEm±	1.82	4.03	3.85	1.61	4.17	2.46	0.20	0.33	0.20	1.44	1.05	0.88
C.D. (P=0.05)	5.40	NS	NS	5.67	NS	NS	0.59	NS	NS	NS	NS	NS
Plant population												
75% Rec.	31.4	37.4	34.0	104	122	113	8.18	7.47	7.90	26.9	27.9	28.0
100% Rec.	52.6	39.4	46.0	108	116	112	8.33	7.12	7.70	31.3	29.6	31.0
125% Rec.	67.4	61.2	64.0	107	119	113	8.13	6.93	7.60	27.5	29.7	29.0
200% Rec.	103.0	86.9	95.0	104	124	114	7.29	6.92	7.10	28.0	30.0	29.0
SEm±	1.98	5.14	5.43	1.98	30.2	2.84	0.19	0.23	0.23	1.64	0.95	0.88
C.D. (P=0.05)	5.88	15.29	16.8	NS	NS	NS	0.56	NS	NS	NS	NS	NS
Interaction												
SEm±	3.44	8.92	7.65	3.42	5.59	4.92	0.34	0.40	0.40	2.84	1.65	1.52
C.D. (P=0.05)	10.21	NS	NS	10.16	NS	NS	NS	1.19	NS	NS	NS	NS
C.V.(%)	9.4	27.5	28	5.61	8.06	13.95	7.31	9.82	15.25	17.3	0.72	17.95

Table 2. Effect of tillage and plant population on yield and oil content of sunflower in rice fallow vertisols

Treatment	Seed yield (kg ha ⁻¹)		Stalk yield (kg ha ⁻¹)		Oil content (%)		Oil yield (kg ha ⁻¹)		
	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled
Tillage									
Conventional	523.0	424.0	474.0	861	1192	1027	39.8	36.5	38.1
Reduced	578.0	390.0	484.0	1104	1365	1235	39.7	38.4	39.0
Minimum	248.0	320.0	284.0	685	1317	1001	35.6	37.5	36.5
SEm±	13.7	16.0	22.64	49.1	44.9	32.9	0.66	0.72	0.67
C.D. (P=0.05)	40.6	62.8	89.0	145.9	NS	129.3	1.96	NS	NS
Plant population									
75% Rec.	398.0	337.0	368.0	790	1258	1024	39.9	35.6	37.8
100% Rec.	558.0	470.0	514.0	1054	1380	1217	38.1	37.4	37.8
125% Rec.	440.0	388.0	414.0	892	1272	1082	36.7	37.9	37.3
200% Rec.	402.0	317.0	360.0	797	1255	1026	38.7	38.8	38.7
SEm±	19.3	21.5	24.14	36.7	47.5	38.0	0.75	0.78	0.78
C.D. (P=0.05)	57.3	63.9	74.41	109.6	NS	NS	2.23	NS	NS
Interaction									
SEm±	33.4	37.3	39.21	63.9	82.2	65.8	1.29	1.35	1.34
C.D. (P=0.05)	19.3	110.8	NS	190.0	NS	NS	3.83	NS	NS
C.V. (%)	12.9	17.1	41.7	12.5	11.0	25.8	5.84	6.26	10.8

Table 3. Interaction effect of tillage and plant population on seed yield (kg ha⁻¹) of sunflower in rice fallow Vertisols during 1996-97 and 1997-98

Tillage/plant population	1996-97					1997-98				
	75% rec.	100% rec.	125% rec.	200% rec.	Mean	75% rec.	100% rec.	125% rec.	200% rec.	Mean
Conventional	480	641	483	487	523	313	634	333	417	424
Reduced	441	735	645	493	579	323	433	494	310	390
Minimum	273	299	193	226	248	375	343	338	225	320
Mean	398	558	440	402		337	470	388	317	
SE _{mt}			33.4					37.3		
C.D. (P=0.05)			99.3					110.8		

recommended population can not compensate the yield that is achieved under 100% recommended plant population.

Interaction of tillage and plant population

During 1996-97, the interaction effects between tillage and plant population were found to be significant in respect of seed and oil yield (Table 3). The reduced tillage with 100% recommended population recorded the highest seed (735 kg/ha) and oil yield (290 kg/ha), respectively. Similarly during 1997-98, seed and oil yield was significantly higher (634 kg/ha and 227 kg/ha, respectively) with conventional tillage in combination with 100% recommended plant population. The mean seed yield over two years recorded a marginal increase in reduced tillage over conventional tillage, and recommended plant population has resulted in higher yield. Any reduction or increase in plant population adversely affected the seed yields.

The overall lower yield levels of the crop in vertisols may be due to higher stickiness of soils which might have interfered in prolific root distribution and development of sunflower crop while the plant emergence and plant population was normal to the treatments. The effect is seen with the reduction of plant height and capitulum's diameter thereby affecting seed setting and filling resulting in lower test weight and final yield (Reddy and Sudhakara Babu, 1999).

Conventional tillage and reduced tillage operations are equally effective on the productivity of sunflower. Since the cost of one ploughing can be minimized in reduced tillage, it is more economical and can be recommended. Further, seed rate recommended for normal crop can also be used for growing sunflower in rice fallows.

REFERENCES

- Krishna, A. and Ananda Reddy, K. 1997. *Indian J. agric. Sci.*, 67 (12) : 551-553.
- Pratibha, G., Pillai, K.G., Satyanarayana, V. and Mir Mustafa Hussain. 1994. Sustainability in oilseeds, *Indian Society of Oilseeds Research*, : 297-301.
- Reddy, G.H.S. and Reddy, A.A. 1979. Causes for low yields of groundnut in six districts of Andhra Pradesh. Survey report, Andhra Pradesh Agricultural University, Hyderabad.
- Reddy, B.N. and Sudhakara Babu, S.N. 1999. Proc. International Symposium on sunflower and other oilseed crops in developing countries., February, 9-12, 1999, Maputo, Mozambique : 120-126.
- Sarkar, R.K., Chakravarthy, A. and Bala, B. 1995. *Indian J. Agron.*, 40 (4) : 657-659.
- Shah, S., Murthy, B.T.S. and Jha, K.P. 1988. *J. Oilseeds Research*, 15(2) : 288-292.

WEED MANAGEMENT IN PUDDLE-SEEDED RICE

D.K. Roy

*Department of Agronomy
CCS HAU, Hisar-125004, Haryana*

ABSTRACT

Field experiment was conducted during dry seasons of 1997 and 1998 at Deep Water Rice Research Station, Bihar. The herbicides-Butachlor, Pendimethalin (each at 1.0 and 1.5 kg a.i. ha⁻¹), Anilophos (at 0.30 and 0.45 kg a.i. ha⁻¹) were compared with hand weeding twice (at 20 and 40 DAS), weed free and unweeded check. Twice hand weedings (at 20 and 40 days after sowing) and Anilophos at 0.45 kg a.i. ha⁻¹ were found similar to weed free treatment with respect to weed control and grain yield of rice. Among the herbicides tested, Anilophos was found to be most effective in controlling weeds and thus increasing the grain yield of rice. Weed control efficiency was better at the higher rates of herbicide application than at respective lower rates. On an average, 49% loss in grain yield was recorded due to uncontrolled weeds over weed free conditions.

Key words : Weed management, puddle rice.

In Bihar, about 1 million hectares area is under rainfed deep water rice ecosystem and is risk prone due to environmental hazards. The productivity of these areas is very low. Of the several reasons for low yield, inadequate weed control is to be considered the major one. The degree of crop weed competition and extent of weed losses vary with rice cultivation systems. Moorthy and Manna (1984) reported that unchecked weed growth reduced the grain yield of puddle seeded rice by 51.3 per cent weed control is critical but difficult in rice growth from pre-germinated seeds broadcast on puddled field (De Datta, 1986). Since manual weeding and other methods are expensive and labour intensive, herbicides are the only effective alternatives. Therefore, the present investigation was carried out to evaluate herbicides for their weed control efficiency.

MATERIALS AND METHODS

A field experiment was conducted during dry seasons of 1997 and 1998 at Deep Water Rice Research Station, Bihar. The soil was silty clay

in texture having pH 7.8, organic carbon 0.49% and the available N, P₂O₅ and K₂O 177, 15.3 and 238.5 kg ha⁻¹, respectively. The herbicides tested were Butachlar and Pendimethalin each at 1.0 and 1.5 kg a.i. ha⁻¹, Anilophos at 0.30 and 0.45 kg a.i. ha⁻¹ and these were compared with hand weeding twice at 20 and 40 days after sowing (DAS) and unweeded check. The nine treatments were tried in a randomized block design and replicated thrice. The deep water rice variety 'Janki' was sown in rows 20 cm apart using a seed rate of 100 kg ha⁻¹ in the last week of February. The herbicides were applied a day after sowing with the help of hand operated Knapsack sprayer in spray volume of 800 litres water ha⁻¹. Hand weeding was done with the help of a small hand tool locally known as Khurpi. Dry weight of weeds was recorded from 0.25 m² area at harvest. Yield contributing characters, grain and straw yields were also recorded. Weed Control Efficiency (WCE) and Weed Index (WI) computed using the following standard formula :

$$\text{WCE \%} = \frac{\text{Weed dry weight in weedy plot} - \text{Weed dry weight in treated plot}}{\text{Weeds dry weight in weedy plot}} \times 100$$

$$\text{WI \%} = \frac{\text{Grain yield of weed free plot} - \text{Grain yield of other treatment}}{\text{Grain yield of weed free plot}} \times 100$$

Table 1. Effect of weed control treatment on grain and straw yield, harvest index, dry weight of weeds at harvest, weed control efficiency (WCE) and weed index (WI) of direct sown rice under puddled conditions (Pooled over 1997 and 1998)

Treatments	Rate of application (kg a.i. ha ⁻¹)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)	Weed dry weight at harvest (t ha ⁻¹)	WCE (%)	WI (%)
Butachlor	1.00	1.48	4.46	24.92	2.10	56	37
	1.50	1.63	4.62	26.08	1.82	62	30
Pendimethalin	1.00	1.33	4.28	23.71	2.22	54	43
	1.50	1.45	4.31	25.17	1.68	65	38
Anilophos	0.30	1.65	4.51	26.79	1.16	76	29
	0.45	1.98	4.96	28.53	1.05	78	15
Hand weeding at 20 and 40 DAS	-	2.19	6.34	25.67	0.96	80	06
Weed free	-	2.34	6.62	26.12	0.00	100	-
Unweeded check	-	1.21	4.16	22.53	4.78	-	48
S.E.m.±	-	0.14	0.40	1.12	0.17	-	-
C.D. (P=0.05)	-	0.41	1.18	3.16	0.49	-	-

Table 2. Effect of weed control treatment on yield attributes in puddle-seeded rice (Pooled data 1997 and 1998)

Treatments	Rate of application (kg a.i. ha ⁻¹)	Panicles (m ⁻²)	Panicle length (cm)	Panicle weight (g)	Filled grains panicle ⁻¹	Unfilled grains panicle ⁻¹
Butachlor	1.00	383	18.5	1.44	44.5	74.4
	1.50	402	19.7	1.81	49.8	63.6
Pendimethalin	1.00	380	18.2	1.38	39.4	76.7
	1.50	393	18.8	1.72	48.3	65.6
Anilophos	0.30	395	19.4	1.92	56.3	52.8
	0.45	405	20.5	2.14	67.5	46.4
Hand weeding at 20 and 40 DAS	-	389	19.8	2.08	53.5	48.6
Weed free	-	420	20.7	2.14	66.8	42.5
Unweeded check	-	170	18.1	1.28	25.7	87.4
S.E.m.±	-	18	0.64	0.07	4.2	3.0
C.D. (P=0.05)	-	52	1.78	0.19	12.3	8.8

RESULTS AND DISCUSSION

Weed flora

The major weed flora recorded in the experimental field consisted of *Cyperus rotundus* L., *Cyperus difformis* L., *Cyperus iria* L. in sedges; *Hydrilla verticillata* (L. fl) Royle in broad leaved weeds; *Echinochloa crusgalli* (L.) Beau., *Echinochloa colunum* (L.) Link and *Panicum repens* L. in grasses.

Effect of herbicides on weeds

All the weed control treatments significantly influenced the biomass of the weeds (Table 1). Weed dry weight in unweeded plot was significantly higher than the weed control treatments. Weed free plot recorded the lowest dry weight and highest WCE followed by hand weeding at 20 and 40 DAS. Among the herbicides, the application of Anilophos @ 0.45 kg a.i. ha⁻¹ recorded the highest WCE (78%) and the lowest weed index (15%). Herbicide treatments effectively controlled different species of *Echinochloa*. Similar results were reported by Mohammad Ali *et al.* (1985).

Effect of herbicides on yield and yield components

Weed free treatment recorded the highest grain yield which was at par with hand weeding at 20 and 40 DAS, and Anilophos @ 45 kg a.i. ha⁻¹ but significantly more than remaining treatments. Higher grain yield in weed treatment

was primarily due to higher number of filled grains, panicle weight and productive tillers. Anilophos @ 0.45 kg a.i. ha⁻¹ was on par with Anilophos @ 0.30 kg a.i. ha⁻¹, Butachlor @ 1.50 kg a.i. ha⁻¹ and hand weeding twice. On an average, 49% loss in grain yield was recorded due to uncontrolled weeds over weed free conditions (Table 1).

The lower grain yield in unweeded check was due to more number of unfilled grains panicle⁻¹ and lesser panicle length, panicle m⁻², panicle weight and grain weight (Table 2). Severe infestation of weeds in rice field leads to higher competition for space, light and nutrients and thus resulting in reduced tillering and decreased crop yield (Bhol and Singh, 1987). Herbicides at higher rate of application gave higher grain yield compared to the lower rate, due to better weed control efficiency and improved growth characters, as reported by Kumar and Gautam (1986) and Vijayaraghavan *et al.* (1988). The superiority of weed free, hand weeding and herbicides over unweeded check in increasing grain yield have also been reported by Raghupathi *et al.* (1992). It is concluded that hand weeding twice, and Anilophos @ 0.45 kg a.i. ha⁻¹ was more effective in controlling weeds and consequently increasing the yield of puddle-seeded rice.

REFERENCES

- Bhol, B.B. and Singh, K.N. 1987. Effect of method of seedling and herbicide application in upland direct seeded rice growth, yield attributes and yield. *Indian J. Agron.*, **32** : 140-143.
- De Datta, S.K. 1986. Technology development and the spread of direct-seeded flooded rice in South East Asia. *Expt. Agric.*, **22** : 417-426.
- Kumar, J. and Gautam, R.C. 1986. Effect of various herbicides on yield and yield attributes of direct seeded rice on puddled soils. *Indian J. Weed Sci.*, **18** : 54-56.
- Mohammad Ali, A., Sankaran, S., Sudhakara, R. and Bhanumurthy, V.G. 1985. Time of application on *Echinochloa crusgalli* (L.) and *Cyperus difformis* L. in lowland direct sown rice. *Indian J. Weed Sci.*, **20**(3) : 1-8.
- Moorthy, B.T.S. and Manna, G.B. 1984. Herbicides of weed control in puddle-seeded rice. *Indian J. Weed Sci.*, **16** : 148-155.
- Raghupathi, S., Kathiresan and Thiruvvarasan, E. 1992. Management of plant population and weeds in direct sown rice cv. ADT-38. Abs. Annual Conf. Indian Soc. Weed Sci. held at Haryana Agric. Univ., Hisar, March 3-4, pp. 48.
- Vijayaraghavan, C.R., Uthaya Kumar, B. and Ranganathan, T.B. 1988. Weed control in direct seeded rice under puddled condition. *Int. Rice. Res. Newsl.*, **13**(5) : 35.

INFLUENCE OF PLANTING PATTERNS AND INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE AND QUALITY OF RAINFED PEARLMILLET

V.S. RATHORE, PANJAB SINGH AND R.C. GAUTAM

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

A field experiment was conducted to study the effect of planting patterns and nutrient management on yield, N and P uptake and protein yield in grain of pearl millet. PR system of planting registered significantly higher grain yield over R & F and uniform row system of planting. Highest N and P uptake and protein yield was obtained with PR system of planting. Maximum increase in grain yield, nutrients (N and P) uptake and protein yield was recorded with application of 60 kg N + 40 kg P_2O_5 closely followed by application of 30 kg N 40 kg P_2O_5 /ha combined with dual inoculation of biofertilizers (*Azospirillum* + PSB).

Key words : Planting patterns, INM, nutrient uptake, quality, pearl millet.

Due to various reasons like drought escaping mechanism low water requirement and ability to grow on low fertile soil, pearl millet (*Pennisetum glaucum* L. R.Br. Emend Stuntz) is one of the most preferred crop in rainfed areas. Its average yield is very low mainly because of soil moisture deficit usually at critical stages of crop growth, beneficial effect of modified planting patterns on yield of rainfed pearl millet were reported by several workers (Aune, 1992, Kaushik and Gautam, 1994). Sufficient information is available on response of pearl millet to chemical fertilizers. However, limited information is available on integrated nutrient management. Also due to escalation of fertilizer price, INM approach would be more remunerative for getting higher returns with considerable fertilizer economy. Keeping in views these facts, the present investigation was carried out to study the effect of planting patterns and INM on yield, nutrient uptake and quality of rainfed pearl millet.

MATERIALS AND METHODS

A field experiment was conducted during the *kharif* season of 2001 and 2002 at Indian Agricultural Research Institute, New Delhi. The soil was sandy loam with 7.3 pH and 0.28% organic carbon and 105.8, 10.25 and 235 kg/ha

of available N, P and K, respectively. The treatments comprised 4 planting patterns [P_1 - uniform row spacing (URS-50 cm), P_2 - ridge and furrow (R and F-50 cm); P_3 - paired row spacing (PRS-30/70 cm) and P_4 - paired row + one row of cowpea] as main plots and 6 nutrient management treatments (N_0 - control, N_1 - RDF (60 kg N + 40 kg P_2O_5 /ha, N_2 - $\frac{1}{2}$ RDF - 30 kg N + 20 kg P_2O_5 /ha, N_3 - $\frac{1}{2}$ RDF + *Azospirillum*, N_4 - $\frac{1}{2}$ RDF + PSB, N_5 - $\frac{1}{2}$ RDF + *Azospirillum* + PSB) as sub plot treatments. The treatments were laid out in split plot design replicated thrice. Pearl millet hybrid 'Pusa 322' was sown on 2nd July 2001 and 28th July, 2002. The total rainfall during the crop season was 410 mm in 2001 and 245 mm in 2002. Chemical and biofertilizers were applied as per treatments.

RESULTS AND DISCUSSION

Productivity

Grain and stover yield of pearl millet increased significantly due to modified planting patterns and highest values were associated with paired row system of planting. Next best treatment was paired row + intercrop system of planting. Ridge and furrow system of planting recorded significantly higher grain and stover yield over uniform row system of planting. This increased productivity of pearl millet under these

Table 1. Yield, nutrient uptake and protein yield of pearl millet as influenced by planting pattern and nutrient management

	Yield (q/ha)				Total N uptake (kg/ha)		Total P uptake (kg/ha)		Protein yield (kg/ha)	
	Grain		Stover		2001	2002	2001	2002	2001	2002
	2001	2002	2001	2002						
Main plots (Planting patterns)										
P ₁ - URS	22.8	17.4	67.7	52.4	71.9	53.3	6.6	5.0	221.2	166.4
P ₂ - R and F	26.9	20.9	71.6	57.7	80.8	64.3	7.6	6.1	258.2	200.6
P ₃ - PRS	31.7	25.8	76.2	62.4	94.0	74.7	8.9	7.0	307.5	250.9
P ₄ - PR-1	30.5	25.4	75.0	61.1	90.2	73.5	8.6	7.0	302.0	249.2
SEm±	0.4	0.4	0.9	0.9	2.5	2.4	0.1	0.1	6.3	6.1
C.D. (P=0.05)	1.4	1.5	3.8	3.3	8.7	8.2	0.4	0.4	21.9	21.3
Sub-plot (Nutrient management)										
N ₀ - Control	21.3	18.7	63.1	51.8	65.2	55.5	5.8	5.1	202.4	173.9
N ₁ - RDF* (60 kg N + 40 kg P ₂ O ₅ /ha)	32.1	24.9	82.5	62.9	100.1	76.9	9.8	7.2	321.1	249.0
N ₂ - ½ RDF (30 kg N + 40 kg P ₂ O ₅ /ha)	25.9	20.6	66.9	55.8	77.4	60.0	7.1	5.8	248.6	197.8
N ₃ - ½ RDF + Azospirillum	29.7	23.1	71.7	59.0	87.5	68.9	8.3	6.1	288.1	221.8
N ₄ - ½ RDF + PSB	27.1	22.5	70.7	58.4	80.6	68.0	8.1	6.4	260.4	216.6
N ₅ - ½ RDF + Azospirillum + PSB	31.7	24.6	80.1	62.2	97.2	73.9	9.6	7.3	310.7	243.5
SEm±	0.4	0.5	1.2	1.1	4.4	3.4	0.5	0.3	9.9	7.6
C.D. (P=0.05)	1.2	1.3	3.4	3.3	12.5	9.6	1.4	0.7	28.4	21.9

*RDF = Recommended dose of fertilizer.

planting systems apparently resulted from their favourable effects on various growth and yield components due to increased availability of moisture. These results corroborates the finding of Aune (1992), Kumar *et al.* (1993).

The recommended dose of fertilizer (60 kg N + 40 kg P₂O₅/ha) gave the highest grain and stover yield of pearl millet. Integration of ½ recommended dose through chemical fertilizers with dual inoculation of biofertilizers (*Azospirillum* + PSB) produced grain yield of pearl millet at par with that of recommended dose of fertilizers. The significant increase in grain yield might be attributed to remarkably improvement in growth and yield attributes due to increased availability of nutrients under aforesaid treatments. While increase in stover and biological yield might be attributed to vigorous growth and dry matter accumulation under these treatments. The similar findings were also reported by Hussain and Reddy (1985), Gautam (1889).

Nutrient uptake

Uptake of N and P by pearl millet was markedly increased due to modified planting systems. Maximum N and P uptake by pearl millet was observed with paired row system of planting closely followed by paired row + intercrop system of planting. Adequate supply of moisture in general enhance the growth and dry matter production of crop directly as well as indirectly by increasing the availability and utilization of nutrients. Singh and Verma (1996), Kumar *et al.*, (1995b) also reported similar findings.

Nutrient management significantly increased the N and P uptake by pearl millet. RDF (60 kg + 40 kg P₂O₅/ha) recorded highest nutrients uptake. It was on par with application of ½ RDF + *Azospirillum* + PSB. These two treatments remained significantly superior over

rest of treatments during both the years. Though there were no any significant variation in N and P contents in grain and stover of pearl millet, the argued uptake of N and P could be assigned to higher grain and stover yield under aforesaid treatments. Similar findings were also reported by Burton *et al.* (1980), Saini *et al.* (1985) and Nanwal (1991).

Protein yield

The modified planting patterns caused significant improvement in protein yield in grain of pearl millet. Paired row and paired row + intercrop system of planting remained at par. Paired row system of planting recorded maximum protein yield (307.5 kg/ha in 2001 and 250.9 kg/ha in 2001). Minimum protein yield (221.2 kg/ha in 2001 and 166.4 kg/ha in 2002) was recorded with uniform row system of planting.

Application of various combinations of chemical and biofertilizers resulted in significant improvement in protein yield by pearl millet grain. Application of RDF (60 kg N + 40 kg P₂O₅/ha) realized maximum protein yield. The difference between RDF and ½ RDF combined with dual inoculation of biofertilizers (*Azospirillum* + PSB) remained at par. Significant improvement in protein yield under application of nutrients was due to higher grain yield caused by favourable growth and improvement in yield attributes under aforesaid treatments. Obviously protein yield is function of seed yield and protein content of seed.

It may be concluded that an integration of ½ RDF with biofertilizers and paired row system of planting proved to be most effective in improving grain yield, nutrient uptake and protein yield of pearl millet cultivation under rainfed conditions.

REFERENCES

- | | |
|---|---|
| <p>Aune, J.B. 1992. Cultural techniques for millet production in Gourma region of Mali. <i>Norwegian Journal of Agricultural Science</i>, 6(2): 161-169.</p> <p>Burton, G.W., Rabson, R. and Axmonn, H. 1980.</p> | <p>Immediate effect of male and female gamets and nitrogen on five pearl millet grain characteristics. <i>Crop Science</i>, 20: 7-9.</p> <p>Gautam, R.C. 1989. Sustainability of pearl millet cultivars</p> |
|---|---|

- to planting systems and fertility levels under rainfed conditions. *Ann. Agric. Res.*, 10 (4) : 424-425.
- Hussain, Mir Mustafa and Reddy, D. Bhaskar 1985. Studies on yield responses of pearl millet hybrids to dates of sowing and levels of nitrogen. *Indian J. Agron.*, 30 (3) : 384-385.
- Kaushik, S.K. and Gautam, R.C. (1994). Response of rainfed pearl millet (*Pennisetum glaucum*) to water harvesting, moisture conservation and plant population in light soils. *Indian J. Agric. Sci.*, 64 (12) : 858-860.
- Kumar, D., Kaushik, S.K. and Gautam, R.C. 1995b. Effect of soil moisture conservation and weed control on the nutrient and seed yield of pearl millet (*Pennisetum glaucum*) under rainfed conditions. *Indian J. Agron.*, 40 (4) : 604-608.
- Kumar, R., Singh, D.P. and Singh, S. 1993. Pearl millet intercropping as influenced by different sources of fertilizers under rainfed conditions. *Haryana Agricultural University Research Journal*, 1 : 191-197.
- Nanwal, R.K. 1991. Intercropping studies in rainfed pearl millet under different planting systems and fertility levels. Ph.D. Thesis, Division of Agronomy, IARI, New Delhi.
- Saini, S.L., Bishnoi, K.C. and Gill, R.S. 1985. Nutrient use pattern of hybrid and synthetic varieties of pearl millet under nitrogen and phosphorus manuring. *Haryana Journal of Agronomy*, 1(1) : 24-30.
- Singh, P and Verma, R.S. 1996. Nitrogen uptake and quality of pearl millet (*Pennisetum glaucum* L.) as influenced by moisture conservation practices and N-fertilization. *Indian Journal of Soil Conservation*, 24 (1) : 85-89.

ANALYSIS OF STRAW AND STOVER OF DIFFERENT CROPS AS A LIVESTOCK FEED BY THE FARMERS

NAGARATNA BIRADAR

*Regional Station, UAS campus
Indian Grassland and Fodder Research Institute, Dharwad - 580 005*

ABSTRACT

A PRA study was taken up in four villages of Dharwad district to know the farmers' preferences for straw and stover of different crops for utilizing them to feed livestock. Study revealed that *kharif* sorghum stover and little millet straw are preferred most as they secured first rank. Rabi sorghum stover secured second rank followed by khadda, wheat straw and paddy straw. Maize stover is the least preferred one. Amongst *kharif* and rabi sorghum stover, former is preferred as it is superior in terms of taste, less wastage per cent, more juicy, more leafy, has soft leaf sheath and gives more energy to the livestock.

Key words : Straw, stover, farmers preferences.

Much of today's livestock on crop residues. Increased scarcities of common grazing lands led to increased reliance on feeding of crop residues and by-products. Fibrous crop residues (straws) are becoming the basal feedstock for the survival of many village animals. Large quantities of straw are available from cropping and one hectare yield of rice can essentially support the energy needs of one small 350 kg animal for a year, though yields and qualities of straw vary. In absence of better feeds, the proper use of crop residues can, therefore, help to maintain more animals and to retain more nutrients and income in the village. Hence ruminant livestock depends increasingly on crop residues for feed leading to even greater integration of crop and livestock production. Since crop residue based livestock production offers a way to increase of farm families, efforts are made to study the farmers' preferences for straws and stovers of different crops.

MATERIALS AND METHODS

Study was conducted in Dharwad taluk between 1999-2001. A list of villages having primary cooperative milk societies (PCMS) was collected from Karnataka Milk Federation, Lakamanahalli plant of Dharwad district, Karnataka. Out of 35 registered PCMS, 9 were

considered for further analysis and selection. The data with respect to average monthly milk collection of 26 PCMS from 1994-95, 95-96, 96-97, 97-98 and 98-99 were collected. Average of 5 years data on milk collection was calculated for each society to know the volume of business in terms of milk collection. Average mean of 26 PCMS derived and based on this, they were classified as above average and below average milk collected societies. Nine PCMS fall under above average category and CV values for each of these PCMS were calculated to know the consistency in milk collection over 5 years. Depending upon CV values, PCMS were arranged in descending order. Second PCMS-Marewad selected finally as first village was relatively big and influenced by urban area.

Marewad PCMS cover two villages-Marewad and Timmapur and were selected for the study. Two villages Govanakop and Kavalageri not having PCMS were also selected based on their proximity to the study centre. Selection of these villages was felt essential to reduce the error in concluding scientific results. Because it is assumed that villages with PCMS would have more awareness about modern feeding practices and forage technologies.

In each of these four villages, PRA was

carried out with transect, pair wise ranking, small group discussions and resource map tools only after establishing rapport with the farmers of the village. In each village it was ensured to have a heterogeneous group representing different age groups, wealth/economic groups, caste groups and gender. PRA results were then compiled and put together in proper tabular form for more clear presentation.

RESULTS AND DISCUSSION

Farmers reported differences in palatability between straws and stover that form a major part of the ruminant feed and are presented in Table 1. Farmers of the area feed dry stover and straws of different crops. It was felt vital to study the farmers' perceptions towards these fibrous crop residues. The pair wise ranking revealed that hybrid Jowar stover and little millet (*Panicum miliare*) straws were perceived as best dry fodder as they get 1st rank. Rabi sorghum stover, khadda grass, wheat straw and paddy straw were given 2nd, 3rd, 4th and 5th ranks, respectively. Maize stover is the least preferred one as it gets last rank. Regarding stover of kharif and rabi sorghum separate analysis was done and results were presented in Table 2.

Little millet straw, considered, as coarse straw is most preferred as farmers' felt that it is cut when it is relatively green. It is juicier as grown during kharif. It is fed as it is or mixed in hay after threshing in to small pieces. Due to thin stem and high palatability, animals consume it completely; hence there is no wastage. Prasad *et al.* 1993 reported that coarse straw have better OMD than slender straws like rice and wheat due to higher organic cell solubles in them.

Khadda grass refers to dry native grass composed mainly of *Heteropogon* that is cut and stacked to feed during scarcity period. Farmers cut it just before the emergency of panicle that is in October when grass would be soft. It has variety of native grasses including leguminous ones, hence perceived as a very good dry fodder to feed getting third rank.

Wheat straw is preferred over paddy straw in the study area as the former secured fourth rank and the latter fifth rank. Wheat straw is

subjected to threshing to make it small pieces. It is then mixed with hay and fed to ruminants. The choice between paddy and wheat straws varies between regions/areas (Rangnekar, 1993). In some regions, wheat straw is considered superior to paddy straw while in other regions wheat straw is believed to be inferior to paddy straw. These variations are observed not only between different regions of the country (like northern and western India) but they are also observed within a state, where availability alone does not fully explain farmer's choice. In Karnataka, the farmers of Chitradurga district prefer paddy straw over wheat straw, though they grow the latter and is available in plenty but not fed. They purchase paddy straw and feed it to the animals. This is because they perceive that wheat panicles are threshed along with straw and panicles have awn like structure that gets mixed with the threshed material. If livestock consumes it animal health gets affected. Joshi *et al.* (1995) reported that threshing practice adopted could influence the quality of straw. So farmers perceived that due to presence of awns in threshed material, it becomes harmful to feed the animals. Arora *et al.* (1975) reported negative effects of feeding paddy straw on animal health, which is attributed to high selenium content or to presence of mycotoxins or a combined effect.

Farmers least prefer dry maize stover. Reasons perceived by them are high wastage percent (75%) and non-palatability. However, Harika *et al.* (1995) reported that from a nutritional point of view maize stover is better than other straws as it has higher levels of crude protein and has higher digestibility than rice, pearl millet and sorghum.

From the foregoing discussions, it is clear that the farmers' concept of straw quality is related to acceptability and intake of the animal as revealed in percent of wastage when fed. When wastage percentage is considered Little millet is consumed by livestock totally leaving no wastage. Kharif sorghum stover, khadda and wheat straw have 25 per cent wastage levels; paddy straw and rabi sorghum stover percentage of wastage is 50. Maximum percent wastage is observed in case of maize stover, which is least, preferred by the farmers.

As mentioned earlier study area is a sorghum-growing belt and crop is valued both for grain and fodder. Murthy *et al.* (1994) indicated that the contribution of sorghum stover to agriculture and the GNP equals that of sorghum grain. among the straws and stovers mentioned in Table 1, sorghum stover is being utilized at large. Therefore, it was felt crucial to further analyze the farmers' perceptions about it. Moreover in the discussions, farmers were differentiating sorghum stover of kharif and rabi crop. The results in this regard are presented in Table 2.

Farmers of the area take up traditional or improved varieties of sorghum to a greater extent and lesser percent of farmers go for hybrids in *kharif*. During *rabi*, Maldandi (M-35-1) is grown extensively. From Table 2, it is clear that *kharif* sorghum stover was preferred over *rabi*, but as a green fodder *rabi* sorghum was preferred. However, the area under *kharif* sorghum reduced almost by 80 per cent from past 20 years in the study area. Earlier farmers were taking up long duration traditional sorghum varieties in *kharif*. Introduction of short duration varieties was not successful due to gray mold problem and likeliness of the crop to get caught in the rain during grain formation stage.

Also in *kharif* due to well-distributed and assured rainfall in the area, farmers shifted to commercial crops like potato, cotton and chilli switching sorghum to *rabi* season. As a result, livestock are fed with *rabi* sorghum stover though they are perceived as of inferior in quality over *kharif* sorghum stover. From Table 2, it is clear that *kharif* sorghum stover is superior over *rabi* stover in terms of taste, less wastage per cent, more juicy, more leafy, has soft leaf sheath and gives more energy to the livestock.

Present study brought forward the realization of farmers' wisdom and the indigenous possessed by them in selecting straws and stovers. Availability alone does not describe feeding system. Farmers have their own reason to select a particular crop residue. Their capacity to meticulously observe and distinguish between similar feed types like in *rabi* and *kharif* sorghum stover should be acknowledged as one of the powerful tool to be exploited while developing any scientific recommendations. Hence it could be concluded that one should neither dismiss offhand, nor get carried away by various beliefs, notions and practices of farmers that are generally of useful nature and need consideration.

Table 1. Pair wise ranking of fibrous crop residues by the farmers

S.No. Crop residue	1	2	3	4	5	6	7	Waste
1 Kharif sorghum stover	-	1	1,3	1	1	1	1	25
2 Paddy straw	-	-	3	4	2	6	7	50
3 Little millet	-	-	-	3,4	3	3	3	0
4 Rabi sorghum stover	-	-	-	-	4	4	4	50
5 Maize stover	-	-	-	-	-	6	7	75
6 Khadda	-	-	-	-	-	-	6	25
7 Wheat straw	-	-	-	-	-	-	-	25
Frequency of occurrence	6	1	6	5	0	3	2	
Ranks	I	V	I	II	VI	III	IV	

Table 2. Farmers' comparison between *kharif* and *rabi* sorghum stover as a fodder

S.No.	Parameters	Kharif stover	Rabi stover
1	Taste	More tasty	Less
2	Wastage per cent	Less	More
3	Juiciness	More	Less
4	Leafiness	More	Less
5	Leaf sheath in dry stover	More	Less
6	Quality of leaf sheath	Soft	Hard
7	Nutrition	Good	Less
8	As green fodder	Good	Very good
9	Purpose to grow	Mainly for green fodder	Grains and stover to stack
10	Quality of dry stover	Good	Not so good

REFERENCES

- Arora, S.P., Kaur Parvinder, Khirwar S.S., Chopra R.C., Ludri, R.S., 1975, Selenium levels in fodders and its relationship with Degnala disease. *Indian J. Dairy Science*, 28 : 249-253.
- Harika, A.S., Tripathi H.P. and Saxena, V.K., 1995, Maize stover. In : Handbook for straw systems, 1995, Eds. Kiran Singh and J.B. Schiere, ICAR, New Delhi, India : 379-391.
- Joshi, A.L., Doyle P.T. and Oosting S.J. 1995, Variations in the quality and quantity of fibrous crop residues, ICAR, New Delhi and Agricultural University, Wageningen : 9-19
- Murthy, V.R., Rao, K.M. and Vishala Devender, 1994. Sorghum as a dry and green fodder crop in India. In : Variations in the quantity and quality of fibrous crop residues (Eds. Joshi, A.L., Doyle, P.T. and Oosting, S.J.). Proc. National Seminar held at BAIF, Pune, from Feb. 8-9, 1994 : 80-86.
- Prasad, C.S, Sampath, K.T., Shivaramaiah, M.T. and Walli, T.K., 1993, Dry matter intake, digestibility and supplementation of slender and coarse straws - A review. In : Feeding of ruminants on fibrous crop residues. (Eds. Kiran Singh and J.B. Schiere). Proc. International Workshop held at NDRI, Karnal, Haryana, India from Feb. 4-8, 1991 : 188-204.
- Rangnekar, D.V., 1993. Farmers' perceptions of quality and value of feeds-fodder and feeding systems. In : Feeding of ruminants on fibrous crop residues-aspects of treatment, feeding, nutrient evaluation, research and extension, (Eds. Kiran Singh and J.B. Schiere) ICAR and Department of tropical Animal Production, WAU, the Netherlands.

AVAILABILITY OF SULPHUR IN SOME SOILS OF JHARKHAND

BRAJENDRA AND L.M. SHUKLA

Division of Soil Science and Agricultural Chemistry
Indian Agricultural Research Institute, New Delhi 110012

ABSTRACT

Soils from four districts namely Dhanbad, Giridih, Hazaribagh and Ranchi of Jharkhand were analysed for different soil properties such as pH, EC, CEC, Clay, silt, sand OC, Fe_2O_3 , Al_2O_3 , CaCO_3 content and available S. Available sulphur had significant and positive correlation with salt content and CaCO_3 . About 42 per cent variation in sulphate sulphur content could be explained on inclusion of pH, organic carbon, Al_2O_3 and CaCO_3 content. On the basis of SAI, 35 per cent soils were rated low, 25 per cent medium and 40 per cent high in available S.

Key words : Available sulphur, soil properties, Jharkhand soils.

The role of sulphur in crop production particularly in oilseeds and pulses is well documented. Exploitive agriculture making use of high analysis S- free fertilizer has depleted the soils in their sulphur reserve and its deficiency is expected to be more acute in years to come. The importance of sulphur in plateau region of Jharkhand is governed by several factors. The importance gets more prominence since sulphur, which is known for several vital functions in plant, has largely been given secondary importance. It is due to this negligence that of late, sulphur deficiency is cropping up in newer areas. According to Katyal *et al.* (1997), the main causes appear to be accelerated crop removal, organic matter depletion, leaching, fixation in acidic soils and largely use of S-free high analysis NPK-fertilizers. Therefore, there is a widespread deficiency of sulphur in these regions. The overall magnitude of sulphur deficiency in these regions has been reported to be 51 per cent (Sakal *et al.*, 1993). Keeping in view this fact, a study was undertaken to investigate the availability of sulphur in some soils of Jharkhand.

MATERIALS AND METHODS

Surface soil samples (0-15 cm depth) were collected in bulk from twenty different sites from plateau region of Jharkhand comprising the districts of Dhanbad, Giridih, Hazaribagh and Ranchi. The collected samples were air-dried

after mixing it thoroughly. The air-dried samples were passed through 2 mm sieve. The samples were analysed for pH, electrical conductivity, organic carbon, free Fe_2O_3 , free CaCO_3 , clay, silt, sand and available sulphur by adopting standard procedures. The sulphur availability index for each soil was worked out on the basis of formula given by Donahue *et al.* (1977). Based on their index value, the soils were grouped into three categories, viz., low (<6.0), medium (6-9) and high (>9.0) in sulphur availability. Simple correlation and step-wise multiple regression analysis were worked out by standard statistical methods.

RESULTS AND DISCUSSION

Soil characteristics

Soil samples collected from four districts, namely, Dhanbad, Giridih, Ranchi and Hazaribagh of Jharkhand, were found acidic to neutral in reaction and pH varied from 4.53 to 6.96. The electrical conductivity was found to vary from 0.04 to 0.40 dS m^{-1} , with an average value of 0.19 dS m^{-1} . The organic carbon content varied from 0.19 to 1.20 per cent, with a mean value of 0.52 per cent. The cation exchange capacity ranged from 7.50 to 15.65 cmol (p^+) kg^{-1} , with a mean value of 9.54 cmol (p^+) kg^{-1} . The contents of clay, sand and silt ranged from 10.20 to 23.90, 51.70 to 68.10 and 18.60 to 32.80 per cent, with respective mean values of 16.50, 60.23

Table 1. Range and mean values of some important characteristics of the soils

Soil characteristics	Range	Mean
pH	4.56-6.96	
EC (dS m ⁻¹)	0.04-0.40	0.19
OC (%)	0.19-1.20	0.52
CEC (cmol(p ⁺) kg ⁻¹)	7.50-15.65	9.54
Clay (%)	10.20-23.90	16.50
Silt (%)	18.60-32.80	22.87
Sand (%)	51.70-68.10	60.23
Fe ₂ O ₃ (%)	1.50-2.60	1.95
Al ₂ O ₃ (%)	2.90-4.9	3.89
CaCO ₃ (%)	Nil - 0.36	0.22
Sulphate S (mg kg ⁻¹)	13.00 - 26.50	19.10

and 22.87 per cent. The content of Al₂O₃ varied from 2.90 to 4.90 per cent, with an average value of 3.89 per cent. The Fe₂O₃ content was found to range from 1.50 to 2.60 per cent, with a mean value of 1.95 per cent. The content of CaCO₃ varied from 0.00 to 0.36 per cent, with a mean value of 0.22 per cent (Table 1).

Most of the soils are non-calcareous in nature. As far as their soil characteristics are concerned, there is no report available in the literature for soils of Dhanbad, Giridih and Hazaribagh districts. However, in case of soils from Ranchi, almost same ranges of these soil characteristics have been reported by a few workers (Mahto *et al.*, 1992, Singh *et al.*, 1993).

Available sulphur status

The amount of sulphate sulphur in the soils of Jharkhand ranged from 13.00 to 26.50 mg kg⁻¹, with a mean value of 19.10 mg kg⁻¹ (Table 1). The sulphur availability index for each soil was worked out on the basis of a formula given by Donahue *et al.* (1977). Based on their index value, the soils were grouped into three categories, viz., low (<6.0), medium (6-9) and high (>9.0) in sulphur availability. It was observed that out of twenty soils from the four district of Jharkhand state, seven soils were found low, five medium and eight high in sulphur availability. Therefore, on the basis of SAI, 35 per cent soils were rated low, 25 per cent medium and 40 per cent high in

Table 2. Correlation coefficient (r) between soil characteristics and available S

Soil characteristics	Sulphate
pH	-0.176
EC (dS m ⁻¹)	0.267*
OC (%)	-0.218
CEC (cmol(p ⁺) kg ⁻¹)	-0.234
Clay (%)	-0.092
Silt (%)	-0.117
Sand (%)	0.185
Fe ₂ O ₃ (%)	-0.226
Al ₂ O ₃ (%)	-0.095
CaCO ₃ (%)	0.413**

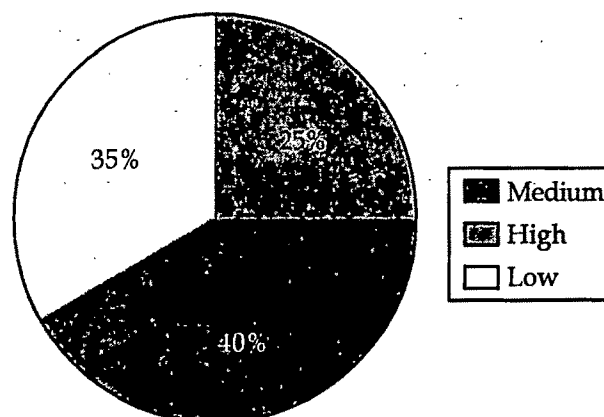


Fig. 1. Status of sulphur in Jharkhand soils

Table 3. Effect of soil characteristics on predictability of different forms of S in Jharkhand soils

Forms of sulphur	Regression equation	R ² × 100
Sulphate S	$y = 23.319 - 0.631x_4 + 11.318x_{10}$	27.30*
	$y = 30.492 - 1.4x_1 - 0.618x_4 + 13.839x_{10}$	39.00*
	$y = 22.481 - 1.842x_1 - 0.706x_4 + 2.788x_9 + 17.104x_{10}$	42.00*

(Where, $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}$ are pH, EC, CEC, OC, sand, silt, clay, Fe₂O₃, Al₂O₃, CaCO₃, respectively)

available S (Fig. 1).

Available S was significantly and positively correlated with EC ($r=0.267^*$) and CaCO₃ ($r=0.413^{**}$) (Table 2). It indicates that with an increase in EC and CaCO₃ content, the concentration of sulphate sulphur is also likely

to increase which is in conformity with the results of Aulakh and Dev (1976), Pandey et al. (1989) and Gowrisankar and Shukla (1999). However, about 42 per cent variation in sulphate sulphur content could be explained on inclusion of pH < organic carbon, Al₂O₃ and CaCO₃ content (Table 3).

REFERENCES

- Aulakh, M.S. and Dev, G. 1976. *J. Indian Soc. Soil Sci.*, **24** : 308-313.
- Pandey, D.K., Tiwari, K.N. and Tiwari, R.C. 1989. *J. Indian Soc. Soil Sci.*, **37** : 161-163.
- Donahue, R.L., Miller, R.W. and Shickluna, J.C. 1977. Soils. In : An Introduction to Soil and Plant Growth. University of Wisconsin, Madison.
- Gowrisankar, D. and Shukla, L.M. 1999. *Commun. Soil Sci. Pl. and Anal.*, **30** : 2643-2654.
- Katyal, J.C., Sharma, K.L. and Srinivas, K. 1997. Sulphur in Indian Agriculture, TSI/FAI/IFA Symposium on Sulphur in Balanced Fertilization, Feb. 13-14, New Delhi.
- Mahto, S.N., Singh, K.P. and Singh, S. 1992. *J. Indian Soc. Soil Sci.*, **40** : 846-847.
- Sakal, R., Singh, A.P., Sinha, R.B. and Bhogal, N.S. 1993. Research Bulletin, Department of Soil Science, RAU, Pusa (Bihar).
- Singh S., Singh, K.P., Rana, N.K. and Sardar, A.K. 1993. *J. Indian Soc. Soil Sci.*, **41** : 562-563.

EFFECT OF DATE OF SOWING ON THERMAL REQUIREMENT OF CRAMBE

S.N. SUDHAKARA BABU, N. MUKTA AND A.R.G. RANGANATHA

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, Andhra Pradesh

ABSTRACT

The performance of 6 accessions of *Crambe abyssinica* under 3 dates of sowing indicated that early sowing on October 31 resulted in higher seed yield due to extended crop duration coupled with significantly higher growth and yield parameters. Due to late sowing on November 30, the crop growth was poor in terms of stalk yield while it had higher productive racemes and thus the highest harvest index. Early sowing accumulated higher (1659) growing degree days (GDD) and GDD decreased with delay in sowing. The *Crambe* accessions varied significantly with respect to growth and yield attributes. The interaction between dates of sowing and *Crambe* accessions was significant only for number of productive racemes.

Key words : *Crambe abyssinica*, sowing date, growing degree days, yield, harvest index.

The demand for vegetable oils is increasing due to increase in population and expanding industrial applications. Non-edible oil crops are important as eco-friendly alternatives to synthetic and nonrenewable mineral sources of oil. Identification and development of speciality industrial oil crops can ease the competition on edible vegetable oils. *Crambe abyssinica* Hochst. ex. R.E. Fries - a relative of the rapeseed, provides high quality lubrication oil that biodegrades rapidly. The crop is extensively cultivated in Europe. *Crambe* oil has distinct advantage in many industrial applications, besides the insecticidal and pharmacological uses (Peterson *et al.*, 2000). The industrial grade oil from *Crambe* is useful as lubricant and in the manufacture of plastics, rubber additives, synthetic fibres and other related products.

Commercialization of novel oil bearing plants is a difficult task and frequently, the new crop is not well suited to local agronomic conditions (Hirsinger, 1989). *Crambe* requires a temperature range of 15-25°C over the main vegetative period although higher temperatures are tolerated except at flowering (Weiss, 2000). *Crambe* is well adapted to warm temperate regimes of colder or drier areas and has been grown commercially and experimentally across a wide climate range. Kmec *et al.* (1998) worked out heat unit requirement of *Crambe* for

determining duration at different locations. The crop is susceptible to frost conditions. The winter season from October to January in Southern India provides moderate thermal regimes for the crop. The present study aims to identify optimum thermal requirement for realizing optimum productivity of the promising *Crambe* accessions under the prevailing climatic conditions at Hyderabad.

MATERIALS AND METHODS

Twenty accessions of *Crambe* were introduced from the North Central Regional Plant Introduction Station, Ames, Iowa, through the National Bureau of Plant Genetic Resources, New Delhi and evaluated at Directorate of Oilseeds Research, Hyderabad (17°15'16" N Lat & 78°18'30" E Long; 540 MSL). Based on the results (Mukta *et al.*, 2000), a field experiment with six promising accessions was conducted during the winter season of 1997 to study the effect of different sowing dates. Factorial combination of 3 dates of sowing (October 31, November 15 and November 30) and 6 *Crambe* accessions (EC 362657, 362664, 362666, 362670, 362671 and 362672) were evaluated in randomized block design with 3 replications. The spacing was 45 cm (row) × 30 cm (plant) and the gross plot size was 3.60 m × 3.15m. The fertilizer dose was 60:40:40 kg N:P₂O₅:K₂O/ha with only

N applied in split (40 kg basal and 20 kg top dress at 30 days after sowing). The crop was grown under irrigation at 10 days interval. The range of minimum and maximum temperatures during the cropping period was 6°C (January 1998) to 13.6°C (November 1997) and 27.1°C (December 1997) to 34.5°C (February 1998), respectively. The thermal requirement of *Crambe* in terms of growing degree days (GDD) for different dates of sowing was worked out using the formula :

$$\text{GDD} = \Sigma[(T_{\text{max}} - T_{\text{min}})/2] - T_b$$

Where, T_{max} = Daily max Temperature (°C); T_{min} = daily minimum temperature (°C); T_b = Base period. T_b for *Crambe* was 2.5°C (Kmec *et al.*, 1998).

RESULTS AND DISCUSSION

Sowing Date

Early sowing on October 31 resulted in highest seed yield of 1518 kg/ha was significantly higher by 43% than late sowing on November 15 and November 30 (Table 1). The highest seed yield of *Crambe* accessions with early sowing on October 31 was due to higher stalk yield (1645 kg/ha) supporting significantly higher number of productive racemes (652/plant) which is a result of good plant growth with significantly highest dry matter production of 50.5 g/plant at 50% flowering stage. Early sowing also resulted in significantly higher total biomass production of 3821 kg/ha. The higher growth and productivity exhibited by the crop in early sowing was due to cool growing and warm post-flowering period resulting in longer crop duration of 95 days. However, the days for 50% flowering remained unaffected by the dates of sowing. Thus the advantage of early sowing was seen in extending the growth stage II (GS II) of the crop that is crucial in contributing to seed filling and yield. The early maturity of *Crambe* under late sowing in November was due to the high temperature regime experienced by the crop especially in GS II, that resulted in early senescence after 50% flowering and thus low yield. The harvest index was significantly higher in late sowing on November 30 (0.49) than early sowing on November 15 (0.41) and October 31 (0.39). This was due to low stalk yield of 590

kg/ha for a seed yield of 1068 kg/ha compared to October 31 sowing.

Crambe accessions

Among the accessions, there were significant differences for growth and yield for different sowing dates. The total crop duration varied significantly from 85 days (EC 362672) to 92 days (EC 362666). The accession EC 362672 was early that took least number of days for 50% flowering (43 days) and maturity (85 days) whereas EC 362666 took maximum number of days for maturity (92 days). There were significant differences between the various *Crambe* accessions for dry matter production at 50% flowering, seed yield and stalk yield. However, the total biological yield and harvest index were similar in all accessions. The accession EC 362657 was highest yielder closely followed by EC 362672 that was significantly higher over EC 362671. The accession EC 362657 recorded highest seed yield of 1426 kg/ha followed by EC 362672 (1372 kg/ha). The other accessions yielded around 11-12 q/ha. Laghetti *et al.* (1995) reported that in a field experiment conducted in Italy, the highest seed yield recorded for *C. abyssinica* was 810 kg/ha.

Interaction

The interaction between dates of sowing and accessions were not significant for most of the economic characters except for number of productive racemes per plant. EC 362666 recorded the highest number of productive racemes per plant with late sowing while EC 362671 recorded the highest number of productive racemes per plant with early sowing (Table 2). EC 362664, 362670 and EC 362671 performed best when the crop was sown early on October 31, whereas later sowing on November 15 and 30 produced less number of productive racemes. Among the three dates of sowing, with the exception of EC 362657, the lowest number of productive racemes per plant were produced in all other accessions for November 15 sowing.

Thermal requirement

Early sowing on October 30 provided higher accumulated GDD (1659) (Table 2). This was due to the increased duration of the crop

Table 1. Performance of *Crambe* accessions under different dates of sowing

Treatment	Days to 50% flowering	Days to maturity	DW at 50% flowering (g/plant)	No. of prod. racemes per plant	Seed Yield (kg/ha)	Stalk Yield (kg/ha)	Total Biomass at harvest* (kg/ha)	Harvest index
Date of sowing								
October 31	55	95	50.5	652	1518	1645	3821	0.39
November 15	55	85	33.6	351	1056	1140	2680	0.41
November 30	55	88	36.7	577	1068	590	2217	0.49
SEm±	0.9	0.5	3.9	45	124	132	294	0.02
C.D. (P=0.05)	NS	1.1	7.7	88.8	247	263	586	0.04
Accession								
EC-362657	59	89	49.7	558	1426	1299	3400	0.43
EC-362664	55	89	35.7	445	1134	1085	2794	0.42
EC-362666	59	92	48.6	642	1116	1141	2787	0.42
EC-362670	58	91	49.8	521	1201	1163	2975	0.41
EC-362671	56	90	45.9	641	1088	1163	2729	0.42
EC-362672	43	85	11.9	355	1372	898	2750	0.48
SEm±	1.3	0.7	5.4	62.9	175	186	415	0.03
C.D. (P=0.05)	2.6	1.5	10.9	125	350	372	NS	NS
Interaction								
SEm±	2.2	1.3	9.4	109	303	323	720	0.05
C.D. (P=0.05)	NS	NS	NS	217	NS	NS	NS	NS
C.V. (%)	7.0	2.5	26.7	23.4	28.4	33.6	28.6	13.8

*Includes chaff and leaf weight; DW =Dry weight.

Table 2. Interaction of sowing date on number of productive racemes of *Crambe* accessions

Treatment	Dates of sowing			Mean
	October 31	November 15	November 30	
EC-362657	448	544	681	558
EC-362664	604	243	488	445
EC-362666	705	441	748	642
EC-362670	734	211	618	521
EC-362671	894	462	566	641
EC-362672	497	206	361	355
Mean	652	351	577	
SEm±		109		
C.D. (P=0.05)		218		
Growing degree days	1659.35	1570.35	1414.90	—

harvesting the natural resources for longer period and thus resulting in higher yield. Delay in sowing had decreased the GDD (1571 and 1415 respectively for sowing on 15th and 30th November respectively). Kmec *et al.* (1998) also found the higher GDD for higher productivity of *Crambe*.

Early sowing in October has resulted in higher seed yield of *Crambe* due to longer crop duration, higher dry matter production and yield attributes. The growing degree days accumulated was higher in early sowing. *Crambe* accession EC 362657 recorded highest seed yield while EC 362672, besides being early, recorded higher seed yield with highest harvest index.

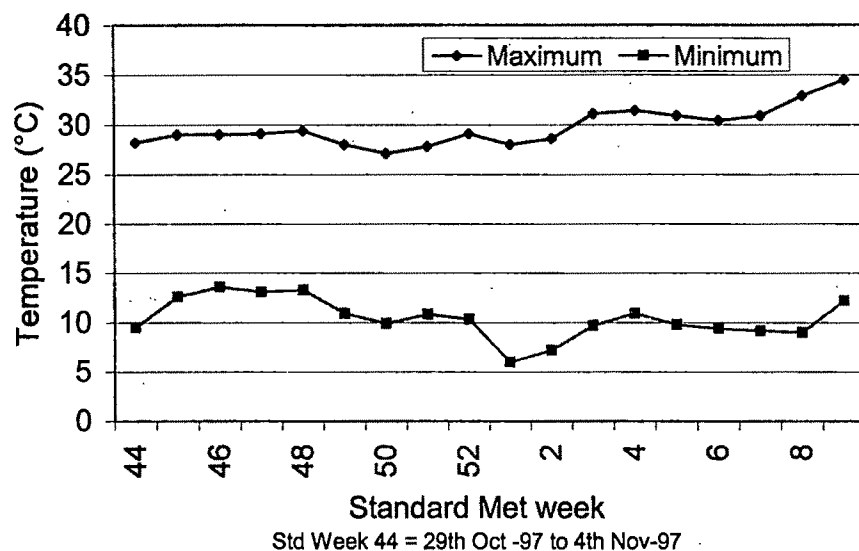


Fig. 1. Mean air temperature during cropping period

REFERENCES

- Hirsinger, F. 1989. New annual oil crops. (in) Robblen G, Downey R.K. and Ashri A. (ed) Oil crops of the world, their breeding and utilization. Mc. Graw-Hill Publ. Co, New York. Pp. 527-529.
- Kmec, P., Weiss, M.J., Milbrath, L.R., Schatz, B.G., Hanzel, J., Hanson, B.K. and Eriksmoen, E.D. 1998. Growth analysis of crambe. *Crop Sci.*, 38(1) : 108-112.
- Laghetti, G, Piergiovanni, A.R. and Perrino, P. 1995. Yield and oil quality in selected lines of *Crambe abyssinica* grown in Italy. *Industrial crops and products*, 4 : 205-212.
- Mukta, N., Ranganatha, A.R.G., Sudhakara Babu, S.N., Joseph Jown, K., Saji, K.V. and Nagaraj, G. 2000. Evaluation of germplasm accessions of *Crambe*, a potential oilseed crop for India. (in) Extended summaries of National Seminar on Oilseeds and Oils-Research and Development needs in the Millennium held during 2-4 February 2000 at Hyderabad, pp. 345-6. Indian Society of Oilseeds Research, Hyderabad.
- Peterson, C.J., Cosse, A. and Coats, J.R. 2000. Insecticidal component sin the meal of *Crmabe abyssinica*. *J. Agric. Urban Entomol.*, 17(1) : 27-36.
- Watkins. C. 1999. Industrial oils *Crambe* - ready to be a commercial success. *Inform*, 10(9) : 833-836.
- Weiss, E.A. 2000. Ed. *Crambe*, Niger and Jojoba. In : Oilseed Crops (2nd edn.). Blackwell Science. Pub. P51.

STUDIES ON APHID DYNAMICS IN MUSTARD CROP WITH REFERENCE TO WEATHER AND PHENOLOGICAL STAGES

SUMANA ROY, S.K. PRASAD* AND N.V.K. CHAKRAVARTY

*Division of Agricultural Physics
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Three varieties of Brassica viz., Agrani, Pusa Jaikisan and Varuna were sown under three sowing dates viz., 1st October, 15th October and 1st November at IARI, New Delhi during rabi seasons of 2000-01 and 2001-02. First crop season experienced relatively warmer temperature during seed filling and pod maturing stage as compared to second crop season. Early sowing resulted in early flowering, early pod development, longer seed filling period and maturity duration. Days taken to maturity were reduced with delayed sowing. Aphid infestation started during either flowering or pod formation stage. Peak population of mustard aphid was mostly found during seed filling stage.

Key words : Apid, dynamics, mustard, weather, phenology.

Rapeseed-mustard is the major oilseed crop of India. The crop occupies an area of approximately 4.83 million hectare with a production of 5.34 million ton (Chakravarty and Gautam, 2002). The average production is quite low in India because of the fact that a large number of insect-pests attack them. Mustard aphid *Lipaphis erysimi* is recognized as a key pest of this crop (Singh *et al.*, 1983). Therefore, the study on variation of aphid population at various phenological stages in relation to favourable weather variables becomes absolutely necessary to decrease the losses and improve crop production.

MATERIALS AND METHODS

Present studies were conducted at the research farm of IARI, New Delhi during rabi seasons of 2000-01 and 2001-02. Three Brassica varieties Agrani, Pusa Jaikisan and Varuna were sown at 15 days interval on 1st October (P1), 15th October (P2) and 1st November (P3) and grown following the recommended cultural practices. The experiment was carried out in a randomized block design with three replicates. The plot size was 4×8m². Phenological events were closely followed by observing the plants on every alternate day. Observations on aphid

population were started from the initiation of aphid infestation and continued till harvest. The data on mustard aphid population were recorded at 5 days interval on 10 cm long main shoot of 6 randomly selected plants per plot.

RESULTS AND DISCUSSION

Weather

Of all the weather factors, since temperatures (maximum and minimum) were found to be the most important, an attempt has been made to critically examine the variation in their pattern during both the seasons. During the rabi 2000-01 (first crop season) the weekly mean maximum temperatures ranged from 16°C during 2nd week of 26°C at 10th week. During October and first fortnight and November the temperatures were relatively higher and then decreased gradually up to third meteorological week. The temperatures increased from 23°C (6th week) to 27°C (12th week). During January (2nd and 3rd week) temperatures dropped suddenly coupled with rainfall. During rabi 2001-02 season (second crop season) the mean daily maximum temperatures were found to be the highest (34°C) during 41st week and the lowest (19°C) at 4th week. In this season also there was a continuous rise in temperature after 4th week, reaching a value of 34°C during 14th week.

*Division of Entomology, IARI, New Delhi.

By comparing the mean daily maximum temperatures, it is observed that in the first crop season, they were about 2°C higher during 6th week and continued to be higher up to 12th week as compared to the second season. The mean daily minimum temperatures of different meteorological weeks during the first crop growth season varied from 4°C in third week to 21°C in 41st week. From third week onwards, minimum temperature increased gradually and attained a high value of 16°C during 13th week. During the second season the temperatures ranged between 3°C (2nd week) and 23°C (41st week). Comparing the minimum temperatures during both seasons, it is found that during first season minimum temperatures were higher by 2 to 3°C during 4th to 49th week and again during 5th to 8th week.

On the whole, it can be said the crop grown in the first season (rabi 2000-01) experienced relatively warmer temperatures as compared to the crop grown in the second season. In the first season, the cultivars Agrani, Pusa Jaikisan and Varuna sown on 1st October took less time for emergence as compared to second season. This may be attributed to the relatively higher maximum and minimum temperatures (by about 2°C) during the emergence period in the first season. Early flowering under 1st October sowing resulted in early pod development, longer seed filling period, maturity duration which ultimately resulted in higher seed yield per hectare than delayed sowing. Similar results were also reported by Tyagi *et al.* (1996).

Aphid population and phenological stages of crop

The mustard aphid (*Lipaphis erysimi*) is the most destructive pest of Brassica which causes considerable yield losses by sucking sap from leaves, inflorescence and growing points. The appearance, spread, peak population and the disappearance of the aphids vary from place to place and were found to have been governed by many weather factors under different agro-ecological conditions (Rana *et al.*, 1993). The variation of aphid population as influenced by sowing dates in the three cultivars during rabi 2000-01 along with the duration of phenological events is presented in figures 1 to 3. The

phenological stages during emergence and peak population are given in Table 1.

Agrani

The aphid started building its population from 14th December which coincided with 75 and 60 DAS in the first and second sowings, respectively. In the third sowing the aphid build up was observed on 19th December. The population remained low up to last week of December and thereafter started increasing. The peak population was observed during January in all the sowings. The first appearance of aphid corresponded with 90% podding, pod formation and early flowering stage of crop in the three sowings, respectively. The peak populations of aphid varied from 314 to 453 per 10 cm of terminal shoot in different sowings and corresponded to seed filling stage in first and second sowing. In third sowing peak population occurred during pod formation stage (Fig. 1).

Pusa Jaikisan

In this cultivar aphid emerged in the second week of December and built up its peak population during last week of January through first week of February. The maximum population per 10 cm terminal shoot was found to be varying from 306 to 503 in the three sowings. As in case of Agrani, in this variety also the peak population occurred at seed filling, seed filling and pod formation stages in the three sowings, respectively (Fig. 2).

Varuna

In Varuna also, the aphid started emerging from 14th December and population gradually increased up to last week of January. The first aphid incidence took place when first, second and third sown plants reached pod formation stage, 70% flowering stage and late vegetative stage, respectively (Fig. 3). The third sown crop was severely infested recording the value of 539 per 10 cm terminal shoot and occurred at the pod formation stage.

From the above results it can be inferred that in 2000-01 rabi season the aphid emerged more or less on the same date (14th December for first and second sowings and 19th December for third sowing) irrespective of cultivars.

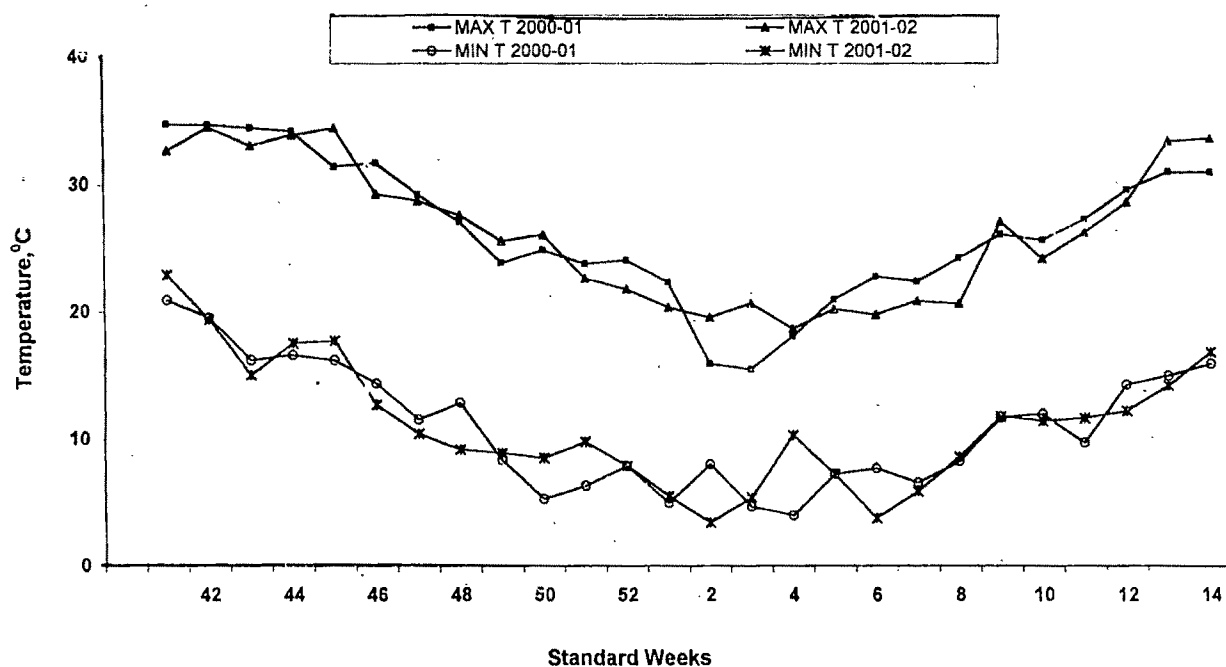


Fig. 1. Aphid population (per 10 cm) and phenological stages in Agradhi (E = Emergence, pod dev. = pod development, seed fill. = seed filling)

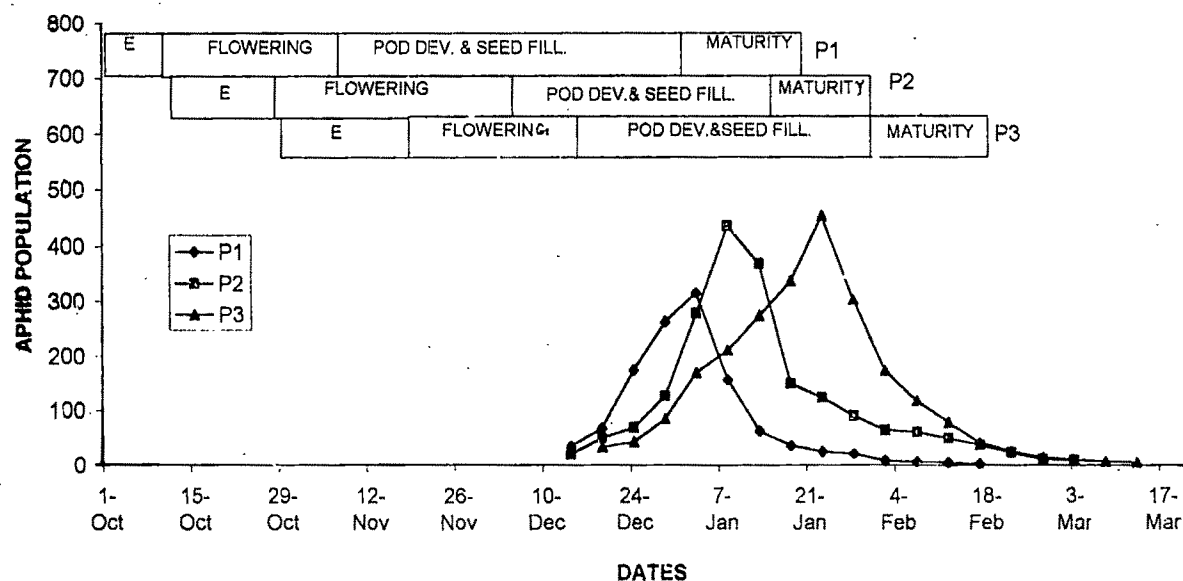


Fig. 2. Aphid population (per 10 cm) and phenological stages in Pusa Jaikisan (E = Emergence, pod dev. = pod development, seed fill. = seed filling)

Among the three cultivars Pusa Jaikisan and Verma were more infested as compared to Agradhi. Regarding the phenological stages during emerging period of aphids, it was found

that the infestation started during either flowering stage or when crop has just started pod formation stage. The peals population was mostly found during seed fulling stage in all the

cultivars. Thus early sown crops escaped infestation because flowering was completed which confirm the earlier studies by Singh *et al.* (1984) from Punjab which revealed that maximum damage due to aphid occurred during flowering period. At Delhi Kar and Chakravarty (1999) found that the aphids started emerging during either 50% to 90% flowering stage or at pod formation stage and the peak population was mostly observed during seed filling stage and our studies also revealed the same. Quite interestingly the aphid population during the second season was observed to be considerably low (below 100 per 10 cm main shoot), though the weather was congenial and remained more or less same as in the previous season. One possible reason for this low population could be that during the second year in the neighbouring plots, mustard crop was grown which had reached the flowering stage much earlier than that in the experimental plots of the study area. This point needs further careful attention while relating the aphid population with weather parameters.

The weather remained conducive for the major part of the season (mid-December to February), facilitating the rapid multiplication of the aphid during both the growth seasons which were in conformity with earlier reports by Prasad and Chakravarty (2000) who observed that the

major period of activity of the aphid population was from the middle of December to the end of February. It can also be noted that in the initial phase, when winged, migrant adults were observed on the plants, the maximum temperatures were around 25°C during both the seasons. The minimum temperatures during this period remained about 7.6 (± 2) °C. During the initial stages of aphid appearance, the morning and afternoon relative humidity values were found to be 93 and 51 per cent, respectively.

Throughout the ascending phase of the aphid population right up to its peak and even a little later (from 1st January when the maximum temperature started showing a downward trend) to about the middle of February (when it had again started showing an upward trend) the maximum temperature remained around 20°C. The minimum temperature also started declining following the trend of maximum temperature. During this period relative humidity remained between 70 to 80 per cent. The weather remained foggy for major part of this period. During the declining phase of the aphid population, the meteorological parameters were not found to be congenial. The maximum temperature started increasing after 20th February and later remained around 25°C. A gradual increase in minimum temperature was also noted. The relative humidity remained around 60 per cent. These

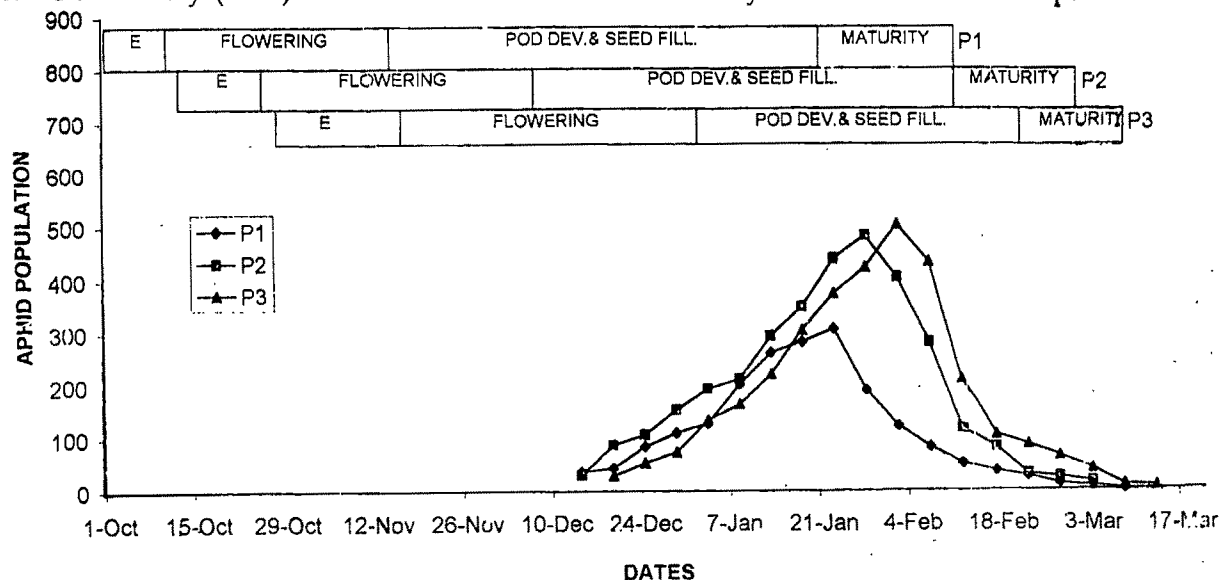


Fig. 3. Aphid population (per 10 cm) and phenological stages in Varuna (E = Emergence, pod dev. = pod development, seed fill. = seed filling)

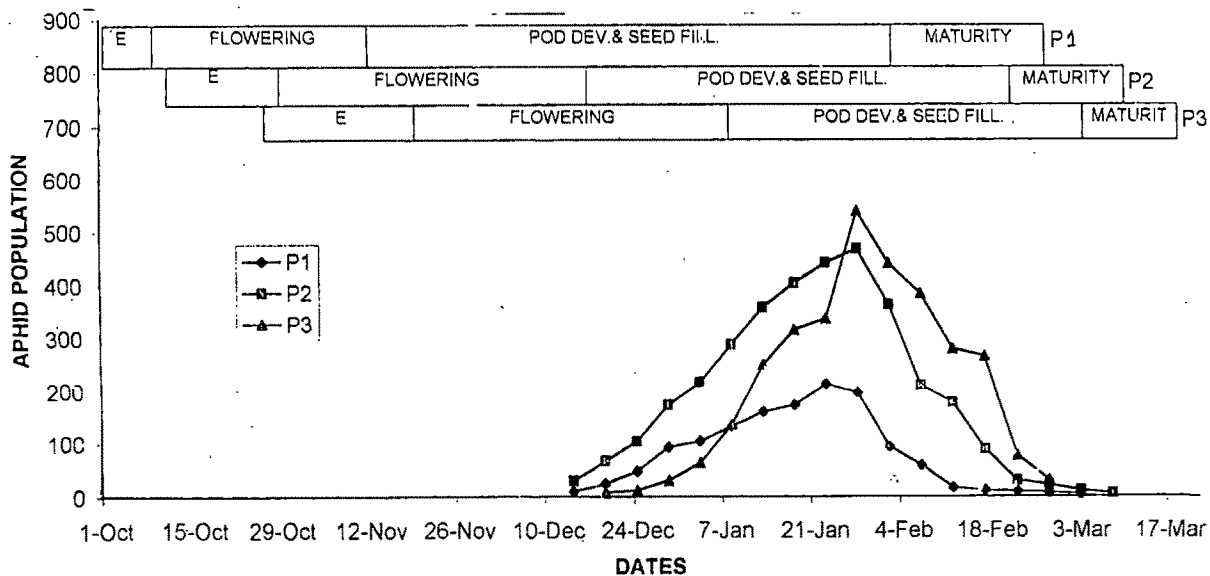


Fig. 4. Aphid population (per 10 cm) and phenological stages in Varuna (E = Emergence, pod dev. = pod development, seed fill. = seed filling)

Table 1. Phenological stages of Brassica spp. during aphid emergence and peak infestation during rabi 2000-01

Treatments	Emergence	Peak population	Peak population per 10 cm terminal shoot
Agrani			
First sowing	90% Podding	Seed filling	314
Second sowing	Pod formation	Seed filling	435
Third sowing	Flowering	Pod formation	453
Pusa Jaikisan			
First sowing	Pod formation	Seed filling	306
Second sowing	90% flowering	Seed filling	482
Third sowing	Flowering	Pod formation	503
Varuna			
First sowing	Pod formation	Seed filling	212
Second sowing	70% flowering	Seed filling	467
Third sowing	Late vegetative stage	Pod formation	539

ambient weather conditions caused rapid decline in the aphid population. The influence of abiotic factors on mustard aphid was studied earlier at IARI, New Delhi, by Kar (1996) who observed

that the maximum, minimum and average temperatures were about 18°C, 7°C and 15°C, respectively at the initial establishment phase.

REFERENCES

- Chakravarty, N.V.K. and Gautam, R.D. 2002. In Forewarning mustard aphid. Cooperating Centre for Mustard. NATP-MMP-17 (Program-6). IARI, New Delhi.
- Kar, G. 1996. Effect of environmental factors on plant growth and aphid incidence in Brassica spp. and modeling crop growth. Ph. D. Thesis, IARI, New Delhi.
- Kar, G. and Chakravarty, N.V.K. 1999. Aphid population on Brassica spp. in relation to phenology and ecological parameters. In Proceedings of National Workshop on Dynamic Crop Simulation Modeling for Agro-meteorological advisory Services.
- Prasad, S.K. and Chakravarty, N.V.K. 2000. A model to predict the aphid population on rapeseed crop. In Proceedings of National Workshop on Dynamic Crop Simulation Modeling for Agro-meteorological advisory Services, 315-320.
- Rana, J.S. Khokar, K.S. Harvir Singh and Sucheta. 1993. Influence of abiotic environment on the population dynamics of mustard aphid (*Lipaphis erysimi* Kalt). *Crop Research Hissar*, 6(1) : 116-119.
- Singh, B., Singh, R., Mahal, M.S. and Brar, H.S. 1983. Assessment of loss in yield of Brassica juncea by *Lipaphis erysimi* (Kalt.) 1. Influence of varying levels of aphid population. *Indian J. Ecol.*, 10 : 97-105.
- Singh, H., Rohilla, H.R. Kalra, V.K. and Yadava, T.P. 1984. Response of Brassica varieties sown on different dates to the attack of mustard aphid *Lipaphis erysimi* (Kalt.). *J. Oilseeds Res.* 1 : 49-56.
- Tyagi, P.K., Singh, D., Rao, V.U.M. and Kumar, A. 1996. Effect of sowing dates on physiological development of Indian mustard (*Brassica juncea* L.) varieties. *Crop Res.*, 11(2) : 151-155.

COMPARATIVE STUDY OF FARMER'S EYE ESTIMATE AND CROP CUT ESTIMATE FOR GENERAL CROP ESTIMATION SURVEYS

TAUQUEER AHMAD, O.P. KATHURIA AND ANIL RAI

Indian Agricultural Statistics Research Institute
New Delhi-110012

ABSTRACT

Difference types of linear models have been fitted in the case of farmer's eye estimate as well as crop cut estimate separately to estimate average yield at block level. It has been observed that the heteroscedastic linear model with intercept term was the best fitted model. On the basis of model fitting it has been observed that there is no significant difference between farmer's eye estimate and crop cut estimate at block level provided the farmer's eye estimate is obtained about a week before the harvest.

Key words : Farmer's eye estimate, crop cut estimate, homoscedastic linear model, heteroscedastic linear model.

Fitting a model to data may be regarded as a way of replacing a set of data values by a set of fitted values derived from the model involving a relatively small number of parameters. In general the fitted value will not be equal to the data value exactly. The discrepancy or goodness of fit is examined by the coefficients of determination (R^2).

Kvalseth (1985) examined the different forms of R^2 . Verma *et al.* (1988) reported that the crop cut method and farmer's eye estimate overestimated the produce by 34% and 3% respectively which raised doubts about the reliability of crop cut method. Therefore, in the present paper, an attempt has been made to fit a model in case of farmer's eye estimate and crop cut estimate separately by using experimental data.

Fitting and estimation of linear models

For comparing the linear models with and without intercept term, R^2 statistic is appropriate because majority of R^2 statistics are equivalent. It is found that among all the models, the heteroscedastic linear model with intercept term was the most suitable model fitted to the data. This model is expressed as :

$$\underline{y} = \underline{1}\alpha + \underline{x}\beta + \underline{u} \quad (2.1)$$

where

$\underline{y}_{n \times 1}$	actual yield;
$\underline{x}_{n \times 1}$	farmer's eye estimate or crop cut estimate;
$\underline{u}_{n \times 1}$	error vector;
α, β	unknown parameters to be estimated;

and $E(\underline{u}) = 0$,

$$\text{Cov}(\underline{u}_i, \underline{u}_j) = 0 \text{ for } i \text{ and } j = 1, 2, \dots, n; i \neq j.$$

$$V(\underline{u}) = \sigma^2 \begin{vmatrix} x_1 & 0 & 0 & \dots & 0 \\ 0 & x_2 & 0 & \dots & 0 \\ 0 & 0 & x_3 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & x_n \end{vmatrix} = \sigma^2 \underline{\delta}$$

where

$$\delta = \begin{bmatrix} x_1 & 0 & 0 & \dots & 0 \\ 0 & x_2 & 0 & \dots & 0 \\ 0 & 0 & x_3 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & x_n \end{bmatrix}$$

Model (2.1) can be rewritten as,

$$\begin{aligned} \underline{y} &= \begin{bmatrix} 1 & \underline{x} \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + u \\ &= \underline{z} \underline{a} + u \end{aligned} \quad (2.2)$$

where

$$\underline{z} = \begin{bmatrix} 1 & \underline{x} \end{bmatrix} \underline{a} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix}$$

The generalized least-square estimator

$$\hat{\underline{a}} = (\underline{z}' \delta^{-1} \underline{z})^{-1} \underline{z}' \delta^{-1} \underline{y}$$

and

$$V(\hat{\underline{a}}) = (\underline{z}' \delta^{-1} \underline{z})^{-1} \alpha^2$$

The unbiased estimate of α^2 is

$$S^2 = [\underline{y}' \delta^{-1} \underline{y} - \hat{\underline{a}}' \underline{z}' \delta^{-1} \underline{y}] / (n-k); k = \rho(\underline{x})$$

and

$$V(\hat{\underline{a}}) = (\underline{z}' \delta^{-1} \underline{z})^{-1} S^2 \quad (2.3)$$

Comparison between farmer's eye estimate and crop cut estimate

The crop cutting was done by State Government following their usual crop cutting practices. However, for farmer's eye estimate and actual produce of the entire field, the data were collected by the field staff drawn from

Indian Agricultural Statistics Research Institute (IASRI) who is well trained in conducting such inquiries as well as collecting data based on actual physical observations.

The data were obtained on wheat crop in Aligarh and Ghaziabad districts of U.P. and Patiala district of Punjab. Fields were selected nearly one month before the harvesting season. During this period the field staff met their first visit to the selected cultivators. This was an introductory visit to solicit the cooperation of the farmers as well as to get an idea about the date of harvest of the selected field. One week before the harvest, the farmers were again contacted to get farmer's eye estimate of the yield. The farmer's eye estimate and actual yield contacted to get farmer's eye estimate of the yield. The farmer's eye estimate to the yield. The farmer's eye estimate and actual yield were straight away available for the entire field while crop cut estimates were obtained by multiplying the standard plot yield by a factor (F) which is the ratio of area of the field to the area of the cut. For studying the efficiency of the two approaches, the data on wheat crop for 10 blocks of three different districts mentioned above are considered. In each block two separate models have been fitted. In the first model actual yield of the crop is dependent variable and farmer's eye estimate of the yield is taken as independent variable, while in the second model dependent variable is same but crop cut yield of the crop is taken as independent variable.

For both the models eye estimate model as well as crop cut model, estimates of parameters and coefficient of determination (R^2) are calculated for each block. The results based on eye estimate model are presented in Table 1 and crop out model in Table 2.

RESULTS AND DISCUSSION

On the basis of the results presented in the Tables 1, 2, it is observed that the value of R^2 is very high in case of linear heteroscedastic model with intercept term in comparison to linear homoscedastic model with intercept term as well as without intercept term. The value of R^2 ranges from 0.9906 to 0.9999 in the case of linear

Parameter Estimate & Values of R^2 statistics for different Models
Table 1. Eye estimate model

Name of the block	$y = \beta x$ (Homoscedastic)			$y = \alpha + \beta x$ (Homoscedastic)			$y = \alpha + \beta x$ (Heteroscedastic)		
	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\alpha}$	$\hat{\beta}$	R^2
Hapur	0	0.9288	0.7315	-5.8250	1.1038	0.7519	-3.8243	1.0386	0.9988
Bhojpur	0	1.1150	0.8796	-3.7825	1.2375	0.8908	-1.2013	1.1304	0.9988
Dadri	0	0.8366	0.9695	3.9576	0.7676	0.9812	4.1774	0.7619	0.9998
Samana	0	0.9341	0.4733	18.1247	0.5409	0.7493	15.4266	0.6028	0.9999
Bhunarhei	0	0.9700	0.9165	0.8853	0.9435	0.9173	-0.3128	0.9829	0.9997
Kharar	0	0.8552	0.7420	4.4093	0.7219	0.7720	1.5378	0.8194	0.9991
Chamkaur Sahab	0	0.8226	0.8643	3.4084	0.7244	0.8835	1.6715	0.7835	0.9991
Sasni	0	0.8786	0.7063	1.1988	0.8400	0.7078	1.6436	0.8254	0.9997
Dhanipur	0	0.8724	0.7707	-0.0414	0.8737	0.7707	1.1566	0.8330	0.9993
Akrabad	0	0.8806	0.8747	1.5467	0.8290	0.8783	1.6593	0.8250	0.9998

Table 2. Crop cut model

Name of the block	$y = \beta x$ (Homoscedastic)			$y = \alpha + \beta x$ (Homoscedastic)			$y = \alpha + \beta x$ (Heteroscedastic)		
	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\alpha}$	$\hat{\beta}$	R^2
Hapur	0	1.0524	0.221	2.1477	0.9752	0.2235	-2.8659	1.1628	0.9963
Bhojpur	0	0.9214	0.3528	-7.3640	1.1632	0.3702	-3.4454	1.0530	0.9936
Dadri	0	1.0560	0.2917	36.1627	-0.0755	0.0008	25.0787	0.2959	0.9906
Samana	0	1.7688	0.3315	14.7846	1.1573	0.6663	14.8233	1.1556	0.9996
Bhunarhei	0	1.6710	0.4268	9.7544	1.1605	0.5449	8.7445	1.2197	0.9980
Kharar	0	1.5577	0.2234	8.3482	1.0889	0.2790	0.8612	1.4793	0.9953
Chamkaur Sahab	0	1.3884	0.2787	-0.6744	1.4259	0.0788	0.8022	1.3430	0.9992
Sasni	0	0.093004	0.2613	41.2528	-0.5332	0.3934	39.0812	-0.4539	0.9992
Dhanipur	0	0.8293	0.2188	15.3530	0.3496	0.1131	6.9805	0.6340	0.9959
Akrabad	0	0.7998	0.4255	6.1560	0.7615	0.4729	6.4386	0.7502	0.9991

heteroscedastic model with intercept term which implies that the fitting of x 's in the above selected model best explains the variance in the y -variable.

For the comparison of eye estimate model and crop cut model (both heteroscedastic linear models), the values of R^2 presented in the Table 1 and Table 2 are compared. It has been observed

that the value of R^2 is nearly same in both the cases which implies that there is no significant difference between eye estimate model and crop cut model provided the farmer's eye estimate is taken one week prior to the harvest. The cultivators of the selected blocks were well educated and well informed in advance about the investigator's visit. Basing on the above facts the difference between the two estimates is found to be insignificant.

CONCLUSION

Among all the linear models fitted to the

data, the linear heteroscedastic model with intercept term is the best fitted model and there is no significant difference between farmer's eye estimate and crop cut estimate provided the farmer's eye estimate is taken one week prior to the harvest. Thus while the farmer's eye estimate may not be solely relied upon to provide an accurate estimate, one may combine crop cut estimates with farmer's eye estimate by using it as auxiliary variable, provided the farmers eye estimate is obtained about a week before the harvest.

REFERENCES

- Kvalseth, T.O., 1985. Cautionary note about R^2 . *The American Statistician*, 39 : 279-285.
- Royal, R.M. (1970). On finite population sampling theory under certain linear regression models. *Biometrika*, 57 : 377-387.
- Searle, S.R. (1971). *Linear Models*, New York, John Wiley and Sons. Inc.
- Verma, V., Merchant, T. and Scott, C., 1988. Longacre report on evaluation of crop-cut methods and farmer reports for estimating crop cut production. Longacre Agril. Development Centre Limited, United Kingdom.

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON DRY MATTER ACCUMULATION NUTRIENT CONTENT AND UPTAKE BY SUNFLOWER

K.M. SUBHA AND GAJENDRA GIRI

*Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

Field experiments were conducted to study the effect of integrated nutrient management on dry matter accumulation nutrient content and uptake by sunflower. Results revealed that application of recommended dose of fertilizer accumulated highest dry matter in sunflower plants. Use of vermicompost alone or in combination with half RDF also recorded significantly more dry matter over half RDF along. N, P and K uptake was highest in RDF applied plots in both the years. Among various combinations, half RDF + cowpea intercrop in 2002 and half RDF + VAM + cowpea and half RDF + vermicompost + VAM in 2003 also registered higher uptake of N. Highest uptake of P was recorded from RDF which was on par with all combinations of organic and biosources in 2002 and half RDF + VAM + cowpea and vermicompost in 2003. These combinations also recorded significantly higher uptake of K over half RDF.

Key words : Sunflower, vermicompost, VAM, cowpea intercrop.

Sunflower is considered as a heavy feeder of nutrients. Within the genetic limits, higher yield of crop plants can be realized under favorable crop environmental conditions specifically with the soil fertility management using manures and fertilizers. The nutrient content and uptake by crop has significant role in augmenting growth and yield. Better uptake and efficient utilization of organic and bio sources of nutrients by crop have been reported by Dayal and Agarwal (1999) and Jones and Sreenivasa (1993). But how these nutrients are diverted from source to sink seeds to be studied. Keeping this in view, an experiment was taken up to study the effect of integrated nutrient management on dry matter accumulation, nutrient content and their uptake by sunflower.

MATERIALS AND METHODS

The field experiment was conducted at the research farm of the Division of Agronomy, IARI, New Delhi during the spring seasons of 2002 and 2003 on spring sunflower (Hybrid MSFH 1754). The soil of the site was sandy loam in texture, low in organic carbon (0.42%) and available

nitrogen (158 kg/ha) and medium in available P (21.5 kg/ha) and K (246 kg/ha) with a pH 7.3.

The experiment was laid out in randomized block design with three replications. Ten treatments viz., control, 50% recommended dose of fertilizer, 100% recommended dose of fertilizer, Vermicompost 5 t ha⁻¹, 50% RDF + Vermicompost 2.5 t ha⁻¹, 50% RDF + VAM, 50% RDF + cowpea intercrop, 50% RDF + 1.25 t ha⁻¹ vermicompost + VAM 50% RDF + 1.25 t ha⁻¹ vermicompost + cowpea intercrop and 50% RDF + VAM cowpea intercrop. Recommended dose of fertilizer (RDF) for sunflower was 80 kg N, 40 kg P₂O₅ and K₂O ha⁻¹. As per the treatments vermicompost was applied to the marked plots and mixed well with the soil. Basal dose of fertilizers, consisting of half the dose of nitrogen and full doses of phosphorus and potassium were applied before sowing and mixed well with soil. The rest half of nitrogen was supplied at 40 DAS. Sunflower seed at the rate of 8 kg ha⁻¹ was sown in rows at 50 cm distance on 1 March and 20 February, in respective years. Plant samples were taken, ground into fine powder and used for

chemical analysis to find out the content of major nutrients in different plant parts and the uptake of these nutrients were estimated at harvest for sunflower.

RESULTS AND DISCUSSION

Dry matter accumulation

Results (Table 1) indicated significant increase in dry matter accumulation by sunflower plants due to the application of recommended dose of fertilizers. Among various combinations of organic and biosources, half RDF + vermicompost + VAM remained on par with RDF at 30 and 60 days in 2003. Rest of the combinations proved to be better than half RDF in enhancing dry matter accumulation by sunflower at 30 days in two years and 60 days in 2003. At 60 days in 2003, half RDF + cowpea and half RDF + vermicompost + cowpea remained on par with RDF. At harvest, vermicompost 5 t/ha, half RDF + vermicompost 2.5 t/ha in both years, half RDF + VAM or cowpea in 2002 and half RDF + vermicompost + VAM or cowpea in 2003 proved to be better than half RDF in respect of dry matter accumulation by

sunflower.

Nitrogen content and uptake

Among different plant parts, leaf and seed contained more N in two years (Table 2). Nitrogen application in the form of recommended dose of inorganic fertilizers significantly enhanced the content of nitrogen in different plants parts of sunflower. This was because of the poor nitrogen status of soil and immediate availability of soluble nitrogen to plants. Combination of half RDF with vermicompost of cowpea intercrop of vermicompost + VAM also enhanced the N content in sunflower plant. But it depended on the dry matter accumulation and therefore, as and when dry matter accumulation was beyond a certain limit, there was reduction in content. This indicated better availability of nitrogen from these sources with the advancement of crop stage.

Uptake of nitrogen followed the pattern of dry matter accumulation in sunflower plant. Early availability of nitrogen from RDF coupled with higher accumulation of dry matter resulted in higher total uptake of nitrogen in this treatment

Table 1. Total drymatter accumulation at different stages of sunflower as affected by integrated nutrient management

Treatment	Total dry matter accumulation (g plant ⁻¹)					
	2002			2003		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Control	1.33	38.67	59.57	0.341	36.04	58.79
Half RDF	1.41	39.83	66.33	0.381	38.62	70.89
RDF	2.08	56.19	92.95	0.894	58.41	106.05
Vermicompost 5 t ha ⁻¹	1.66	46.91	74.95	0.445	51.78	86.89
Half RDF + Vermicompost 2.5 t/ha ⁻¹	1.61	41.86	77.91	0.652	50.57	88.23
Half RDF + VAM	1.68	44.78	75.45	0.597	50.61	73.71
Half RDF + Cowpea	1.69	51.55	78.91	0.666	47.81	78.38
Half RDF + Vermicompost 1.25 t ha ⁻¹ + VAM	1.67	45.33	73.07	0.869	53.90	94.62
Half RDF + Vermicompost 1.25 t ha ⁻¹ + Cowpea	1.58	52.40	73.40	0.478	45.87	81.00
Half RDF + VAM + Cowpea	1.77	44.56	71.19	0.564	50.81	91.11
SEm±	0.05	1.85	2.55	0.022	1.83	2.81
C.D. (P=0.05)	0.15	5.50	7.58	0.065	5.45	8.34

DAS = Days after sowing.

Table 2. Effect of integrated nutrient management on nitrogen content in different plant parts of sunflower at harvest

Treatment	Nitrogen content (%)							
	2002				2003			
	Leaf	Stem	Head	Seed	Leaf	Stem	Head	Seed
Control	1.180	0.454	1.428	2.576	1.260	0.336	0.728	2.226
Half RDF	1.524	0.384	1.428	2.464	1.512	0.346	0.804	2.436
RDF	1.680	0.510	1.680	2.856	1.540	0.364	0.985	2.228
Vermicompost 5 t ha ⁻¹	1.232	0.503	1.316	2.324	1.512	0.308	0.858	2.240
Half RDF + Vermicompost	1.568	0.552	1.652	2.576	1.100	0.336	0.946	2.548
2.5 t/ha ⁻¹								
Half RDF + VAM	1.540	0.386	1.238	2.576	1.260	0.280	0.950	2.828
Half RDF + Cowpea	1.680	0.622	1.204	2.744	1.512	0.364	0.898	2.227
Half RDF + Vermicompost	1.652	0.386	1.624	2.604	1.344	0.349	0.936	2.362
1.25 t ha ⁻¹ + VAM								
Half RDF + Vermicompost	1.662	0.454	1.484	20.886	1.064	0.280	0.940	2.400
1.25 t ha ⁻¹ + Cowpea								
Half RDF + VAM + Cowpea	1.605	0.460	1.484	2.632	1.428	0.364	0.820	2.576
SEM±	0.038	0.013	0.037	0.075	0.048	0.010	0.029	0.090
C.D. (P=0.05)	0.112	0.039	0.109	0.224	0.142	0.029	0.087	0.269

in two years (Table 5). Combination of half RDF with different organic sources proved to be as good as RDF. Treatments viz., half RDF + cowpea remained statistically on par with RDF in respect of N uptake in 2002. Half RDF + vermicompost and half RDF + vermicompost + VAM, half RDF + VAM + cowpea also registered significantly higher values than half RDF in two years. This clearly indicated the time lag between application and availability in respect of organic and bio-sources. Increase in uptake of nitrogen with increased availability was earlier reported by Mrinalini *et al.* (1998). Higher uptake with application of organic manures, apart from supplying nitrogen, increased the availability of native nitrogen and improved soil environment.

Phosphorus content and uptake

P content was found to be more in seed and head in two years. The content of phosphorus in parts of sunflower plants did not follow any set pattern (Table 3). Sunflower seed and head recorded highest P content in the plots where RDF was applied. Whereas combination of half RDF and cowpea recorded highest P content in the plots where RDF was applied. Whereas combination of half RDF and cowpea recorded

highest P content in stem and VAM recorded highest P content in leaf. Combination with VAM also recorded P content in seed comparable with RDF. The improved phosphorus content in treatments involving VAM clearly indicated the role of VAM fungi in solubilizing P and increasing its availability. This capacity of VAM in association with sunflower has been well documented by Chandrasekhara *et al.* (1995) and Jones and Sreenivasa (1993).

Phosphorus uptake (Table 5) by sunflower was higher due to RDF application owing to the higher dry matter accumulation. Combination of various sources viz. half RDF + vermicompost + VAM, half RDF + VAM + cowpea, half RDF + VAM and half RDF + cowpea proved to be efficient in enhancing phosphorus uptake better than or on par with RDF. Uptake of phosphorus was lowest with control and half RDF in both years. The beneficial effect of VAM (Chandrasekhara *et al.*, 1995) and organic manure (Singh *et al.*, 1998) in augmenting phosphorus uptake has earlier been established.

Potassium content and uptake

K content was recorded to be more in head

Table 3. Effect of integrated nutrient management on phosphorus content in different plant parts of sunflower at harvest

Treatment	Nitrogen content (%)							
	2002				2003			
	Leaf	Stem	Head	Seed	Leaf	Stem	Head	Seed
Control	0.080	0.155	0.220	0.755	0.240	0.060	0.240	0.540
Half RDF	0.120	0.220	0.285	0.760	0.240	0.090	0.380	0.690
RDF	0.250	0.155	0.440	0.800	0.360	0.280	0.500	0.610
Vermicompost 5 t ha ⁻¹	0.190	0.190	0.285	0.790	0.290	0.120	0.400	0.595
Half RDF + Vermicompost 2.5 t/ha ⁻¹	0.220	0.185	0.315	0.790	0.440	0.160	0.500	0.755
Half RDF + VAM	0.320	0.250	0.330	0.805	0.500	0.280	0.520	0.570
Half RDF + Cowpea	0.200	0.330	0.220	0.690	0.390	0.200	0.480	0.565
Half RDF + Vermicompost 1.25 t ha ⁻¹ + VAM	0.280	0.220	0.315	0.800	0.370	0.180	0.520	0.530
Half RDF + Vermicompost 1.25 t ha ⁻¹ + Cowpea	0.180	0.200	0.285	0.820	0.460	0.240	0.480	0.595
Half RDF + VAM + Cowpea	0.320	0.225	0.320	0.695	0.540	0.280	0.420	0.755
SE _{mt}	0.008	0.004	0.009	0.021	0.010	0.005	0.011	0.020
C.D. (P=0.05)	0.024	0.013	0.026	0.062	0.031	0.014	0.033	0.058

Table 4. Effect of integrated nutrient management on potassium content in different plant parts of sunflower at harvest

Treatment	Nitrogen content (%)							
	2002				2003			
	Leaf	Stem	Head	Seed	Leaf	Stem	Head	Seed
Control	2.294	1.764	2.522	1.084	1.654	1.659	2.004	1.006
Half RDF	2.454	2.129	2.174	1.263	1.524	1.736	2.134	1.046
RDF	2.500	2.014	2.414	1.273	1.674	1.639	2.207	1.022
Vermicompost 5 t ha ⁻¹	2.414	2.049	2.274	1.232	1.489	1.644	2.149	0.974
Half RDF + Vermicompost 2.5 t/ha ⁻¹	2.323	1.869	2.384	1.295	1.684	1.694	2.159	0.954
Half RDF + VAM	2.394	2.024	2.442	1.229	1.495	1.649	2.117	1.049
Half RDF + Cowpea	2.425	1.944	2.437	1.162	1.659	1.689	2.144	1.012
Half RDF + Vermicompost 1.25 t ha ⁻¹ + VAM	2.250	1.952	2.164	1.161	1.514	1.649	2.169	0.936
Half RDF + Vermicompost 1.25 t ha ⁻¹ + Cowpea	2.385	1.784	2.494	1.184	1.774	1.564	2.514	0.931
Half RDF + VAM + Cowpea	2.400	1.984	2.429	1.226	1.499	1.619	2.294	0.959
SE _{mt}	0.065	0.059	0.067	0.028	0.044	0.048	0.064	0.032
C.D. (P=0.05)	0.194	0.177	0.199	0.082	0.131	0.142	0.189	0.094

and seed. As evident from data in Table 4, potassium content of different parts of sunflower plant did not followed any definite trend. At

most of the stages, RDF application recorded highest values of potassium content. The dilution effect with increase in accumulation of dry matter

Table 5. Nutrient uptake by sunflower at harvest stage as affected by integrated nutrient management

Treatment	Nutrient uptake (kg ha ⁻¹)					
	2002			2003		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Control	49.73	11.78	69.72	48.01	11.17	60.19
Half RDF	60.38	16.17	92.43	64.63	17.26	75.48
RDF	91.94	22.19	123.78	101.40	32.86	104.28
Vermicompost 5 t ha ⁻¹	67.64	19.20	105.05	68.41	28.86	77.09
Half RDF + Vermicompost 2.5 t/ha ⁻¹	72.29	18.30	101.35	72.70	25.09	97.59
Half RDF + VAM	67.61	21.41	104.50	78.41	23.56	80.60
Half RDF + Cowpea	86.31	21.89	110.87	70.10	21.79	72.24
Half RDF + Vermicompost 1.25 t ha ⁻¹ + VAM	76.47	21.81	104.72	84.35	23.23	94.89
Half RDF + Vermicompost 1.25 t ha ⁻¹ + Cowpea	69.77	17.44	91.15	63.17	22.41	79.23
Half RDF + VAM + Cowpea	73.40	19.93	104.13	86.63	31.85	89.28
SE _{mt}	3.10	1.80	2.72	2.30	1.62	2.13
C.D. (P=0.05)	9.21	5.35	8.08	6.83	4.81	6.33

was clear. Since potassium is a highly mobile element in plant system, its concentration in plants parts might have undergone frequent changes. But comparatively higher values obtained for stem and head towards maturity could be explained by the findings of Annaduri et al. (1994) where they could get higher stem girth and sturdiness of stem with application of

potassium.

Potassium uptake by sunflower was highest from RDF applied crop in both years. RDF was able to supply required amount of potassium in available from. Half RDF + vermicompost + VAM treatment also fared comparatively better in enhancing K uptake (Table 5).

REFERENCES

- Annaduri, K., Sheshadri, P and Palaniappan, S.P. 1994. Influence of potassium levels on yield and oil content in sunflower - soybean sequence, *J. Potassium Res.*, **10**(2) : 124-29.
- Chandrashekara, C.P., Patil, V.C. and Sreenivasa, M.N. 1995. VA-mycorrhiza mediated P effect on growth and yield of sunflower (*Helianthus annuus* L.) at different P levels. *Plant and Soil*, **176** : 325-328.
- Dayal, D. and Agarwal, S.K. 1999. Response of sunflower genotypes to nutrient management. *Indian J. Agric. Sci.*, **69** (1) : 10-13.
- Jones, N.P. and Sreenivasa, M.N. 1993. Response of sunflower to the inoculation of VA mycorrhiza and phosphate solubilizing bacteria in black clayey soil. *J. Oilseeds Research*, **10** : 86-92.
- Mrinalini, G., Sreemannarayana, B. and Sreenivasaraju, A. 1998. Effect of nitrogen and sulphur on yield, uptake and N : S ratio in sunflower. *Journal of Indian Society of Soil Science*, **46** (2) : 317-319.
- Singh, Jagdev, Singh, K.P. and Yadav, S.S. 1998. Nutrient-uptake pattern of sunflower (*Helianthus annuus*) as influenced by *Azotobacter*, farmyard manure, nitrogen and phosphorus. *Indian J. Agron.*, **43** (3) : 474-79.

INHERITANCE OF IMPORTANT CHARACTERS IN BACTERIAL WILT RESISTANT × SUSCEPTIBLE TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) CROSSES

K.C. SHARMA

Hill Agricultural Research and Extension Centre
CSK Himachal Pradesh Krishi Vishvavidyalaya, Bajaura - 175 125 (H.P.)

ABSTRACT

Generation mean analysis was used to study the inheritance of economic traits in two tomato crosses viz., Hawaii-7998 × Solan Gola and Hawaii-7998 × Roma. The scaling test indicated the preponderance of epistatic gene effects for all the traits in both the crosses except locules/fruit in Hawaii-7998 × Solan Gola. The study revealed the presence of non-allelic gene interaction among most of the traits. However, additive component was predominant in fruits/plant, pericarp thickness and plant height suggesting the direct selection for the improvement of these traits.

Key words : Tomato, gene action, non-allelic interaction, additive.

Tomato is one of the most popular vegetables being grown all over the world and occupies 3rd position among vegetables in area and production in the world. In the mid hills of Himachal Pradesh, this particular crop is playing an indispensable role in the economic upliftment of hilly farmers in the form of off-season crop. As such, this crop needs special attention and continuous efforts in bringing genetic improvement. For this, an understanding of the mode of inheritance of complex quantitative characters is essential for formulating effective breeding methodology to improve these characters. The estimates of gene effects will help in understanding the genetic potentiality of the population. The present study was undertaken to have a clear understanding of gene effects for important but complex traits in two inter-varietal crosses of tomato.

MATERIALS AND METHODS

The present study was conducted on two crosses viz., Hawaii-7998 × Solan Gola and Hawaii-7998 × Roma. Each cross involved bacterial wilt resistant stable line Hawaii - 7998 as one of the parents whereas other parent involved in the cross represented commercial but susceptible cultivars (Solan Gola, Roma). The F_1 , F_2 , BC_1 and BC_2 generations were transplanted at the Research Farm of Hill Agricultural

Research and Extension Centre, CSK Himachal Pradesh Krishi Vishvavidyalaya, Bajaura, during summer, 2002. The layout design followed was RBD with three replications maintaining a spacing of 75×45 cm. Observations were recorded on economic characters viz., fruit yield per plant (g), fruits/plant, mean fruit weight (g), locules/fruit, pericarp thickness, TSS and plant height from on randomly selected ten competitive tagged plants in P_1 , P_2 and F_1 's and 30 plants in F_2 's and 20 competitive plants in each of the backcrosses (BC_1 and BC_2) generations. The scaling test suggested by Mather and Jinks (1971) was applied for testing the adequacy of the additive dominance model. Hayman (1958) six parameter model and Jinks and Jones (1956) three parameter model were applied for the analysis depending upon the presence or absence of non-allelic interactions.

RESULTS AND DISCUSSION

Analysis of variance indicated the presence of sufficient variation among the generation means for all the characters in both the crosses under study. The A, B, C and D scaling test was done to get the idea of presence of epistasis interaction in the population. Significance of any one or more scale exhibited the presence of non-allelic interactions among the crosses. In such situation 6 parameters viz., m , d , h , i , j and l were estimated. Non-significant estimates of all these

scales suggested the absence of non-allelic interaction, which indicated the estimation of 3 parameters (m, d and h). The scaling test (Table 1) indicated the preponderance of epistatic gene effects for all the traits in both the crosses. The locules/fruit in cross Hawaii-7998 × Solan Gola was under the control of only 3-parameter model.

Both additive and dominance gene effects played an important role for determining majority of the traits in both the crosses (Table 2). The magnitude of dominance gene effects prevailed over their respective additive gene effects for most of the traits thereby suggesting the greater opportunity for exploitation of heterosis. Fageria (1996) and Dod *et al.* (1990) also observed nonadditive gene action in most of the traits in tomato. In some traits like fruits/plant in cross Hawaii-7998 × Solan Gola and pericarp thickness and plant height in Hawaii-7998 × Roma where the additive gene effects were higher than dominance gene effects suggested that it would be easier to select and isolate high performing pure lines for these traits. These results are in line with those of Khattri *et al.* (1990).

Among the epistasis interactions, the study revealed the role of additive × additive (i) gene

interactions in most of the traits. Additive × dominance (j) gene interactions were significant for fruits/plant, mean fruit weight, pericarp thickness and plant height in cross Hawaii-7998 × Solan gola and fruit yield, mean fruit weight, pericarp thickness and locules/fruit in cross Hawaii-7998 × Solan Gola and fruit yield, mean fruit weight, pericarp thickness and locules/fruit in cross Hawaii-7998 × Roma. It was noted that both (h) and (l) components possessed opposite sign between themselves for majority of traits in both the crosses, indicating the presence of duplicate type of gene interaction suggesting thereby that the difficulty would be encountered in selection for these traits. The complementary epistasis for mean fruit weight and TSS in cross Hawaii-7998 × Solan Gola indicated the successful chances of direct selection.

As evident from the results of the present investigation, since nonadditive gene effects contributed more towards the inheritance of most of the traits, heterosis breeding seems to be the most appropriate breeding method for their improvement in tomato. However, additive component was also predominant in few traits (fruits/plant, pericarp thickness and plant height), as such selection may be given greater importance for improving these traits.

Table 1. Estimates of scaling test for different characters in tomato

Characters	A	B	C	D
Hawaii-7998 × Solan Gola				
Fruit yield/plant (g)	-76.33 ± 139.20	-278.67* ± 111.95	75.00 ± 168.72	215.00** ± 69.99
Fruits/plant	-18.28** ± 2.65	-12.35** ± 2.32	-5.20 ± 4.69	12.72** ± 1.71
Mean fruit weight (g)	14.48** ± 4.91	4.74 ± 4.29	1.50 ± 8.46	-8.86** ± 1.67
Pericarp thickness (mm)	0.00 ± 0.04	0.21** ± 0.06	-0.09 ± 0.09	-0.15** ± 0.03
Locules/fruit	0.78 ± 0.71	-0.61 ± 0.41	-0.49 ± 0.80	-0.33 ± 0.37
Total soluble solids (%)	0.75 ± 0.66	0.89 ± 0.58	1.73** ± 0.22	0.04 ± 1.08
Plant height (cm)	-59.33** ± 7.23	-27.00** ± 6.32	71.00** ± 13.70	78.67** ± 6.87
Hawaii-7998 × Roma				
Fruit yield/plant (g)	-250.33** ± 74.34	-11.33 ± 68.74	-1753.00** ± 123.99	-745.67** ± 26.72
Fruits/plant	-6.47** ± 2.90	-4.12 ± 0.21	-65.69** ± 4.04	-27.55** ± 1.76
Mean fruit weight (g)	-2.99** ± 0.23	4.85** ± 1.03	19.16** ± 5.31	8.65** ± 2.74
Pericarp thickness (mm)	0.08** ± 0.02	-0.12** ± 0.03	0.03 ± 0.08	0.03 ± 0.04
Locules/fruit	1.11** ± 0.44	-0.50 ± 0.52	2.16** ± 0.80	0.78* ± 0.29
Total soluble solids (%)	-1.37** ± 0.45	-2.65** ± 0.72	-2.48** ± 0.82	0.77** ± 0.29
Plant height (cm)	-11.33** ± 6.28	-18.33** ± 7.97	99.67** ± 11.09	64.67** ± 6.20

** , * significantly at 1% and 5% level, respectively.

Table 2. Estimates of 6 parameters based on generation mean for different characters in tomato

Characters	m	d	h	i	j	l	Epistatis
Hawaii-7998×Solan Gola							
Fruit yield/ plant (g)	1191.33**±9.24	-13.00±67.50	-41.83±162.39	-430.00**±139.98	101.17±67.99	784.99±318.40	D
Fruits/ plant	33.53**±0.67	2.33**±1.05	-20.03**±3.92	-25.44**±3.42	-2.97**±1.17	56.08**±6.31	D
Mean fruit weight (g)	35.55**±0.43	-3.87**±1.43	21.03**±5.32	17.72**±3.34	4.87**±1.44	4.87**±1.44	C
Pericarp thickness (mm)	0.42**±0.01	-0.15**±0.02	0.21**±0.07	0.31**±0.06	-0.11**±0.02	-0.52**±0.13	D
Locules/ fruit	2.28**±0.10	-0.17±0.09	-0.89**±0.22	-	-	-	-
Total soluble solids (%)	5.90**±0.52	-0.21±0.30	-0.87±2.21	-0.09±2.17	-0.07±0.34	-1.55±2.56	C
Plant height (cm)	116.00**±2.89	-12.00**±3.73	-172.50**±14.23	157.33**±13.74	-16.17**±4.32	243.67**±20.24	D
Hawaii-7998×Roma							
Fruit yield/ plant (g)	694.33**±4.10	-112.33**±25.44	2042.17**±81.44	1491.33**±53.45	-119.50**±26.50	-1229.67**±160.40	D
Fruits/ plant	18.06**±0.57	6.33**±1.33	64.24**±3.90	55.09**±3.53	-1.18±1.38	-44.50**±6.69	D
Mean fruit weight (g)	38.38**±1.32	-10.28**±0.75	-12.40**±5.49	-17.30**±5.48	-3.92**±0.77	15.44**±6.11	D
Pericarp thickness (mm)	0.50**±0.02	0.06**±0.02	-0.07±0.08	-0.07±0.07	0.10**±0.02	0.10±0.10	D
Locules/ fruit	2.17**±0.10	0.89**±0.22	-2.15**±0.68	-1.56±	0.81**±0.25	0.96±1.19	D
Total soluble solids (%)	5.45**±0.03	0.20±0.29	-1.71*±0.71	-1.53±	0.64±0.34	5.55**±1.41	D
Plant height (cm)	108.00**±2.31	23.33**±4.14	-143.50**±12.98	-129.33±	3.50±4.44	159.00**±20.43	D

** * significantly at 1% and 5% level, respectively.

REFERENCES

- Dod, V.N., Kale, P.B. and Wankhade, R.V. 1990. *Haryana J. Hort. Sci.*, 21 : 296-302.
- Fagaria, M.N.S. 1996. *Haryana J. Hort. Sci.*, 25 (4) : 238-244.
- Hayman, B.I. 1958. *Heredity*, 12 : 371-390.
- Jinks, J.L. and Jones, R.M. 1956. *Genetics*, 43 : 223-234.
- Khattra, A.S., Nandpuri, K.S. and Thakur, J.C. 1990. *Indian J. Hort.*, 47 (2) : 210-215.
- Mather, K. and Jinks, J.L. 1971. *Introduction to Quantitative genetics*. Chapman and Hall, London.

GENETIC VARIABILITY IN URDBEAN GERMPLASM

BUPESH KUMAR AND M.N. MISHRA

Department of Plant Breeding and Genetics
R.B.S. College, Bichpuri, Agra, Uttar Pradesh - 283 105

ABSTRACT

The nature and magnitude of genetic variability, heritability and expected genetic advance were studied for eight yield contributing characters in 30 genotypes of urdbean cultivated at Research Farm of R.B.S. College, Bichpuri, Agra. High heritability estimate was observed for plant height, yield/plant, pod length and number of pods/plant while high genetic advance estimate was observed for number of pods/plant, plant height, pod length and yield/plant. These characters are found to be used as selection criteria for genetic improvement of urd bean crop.

Key words : Variability, urd bean, germplasm.

The urdbean is an important pulse crop which serve as a chief source of dietary protein besides minerals and vitamins. Urdbean also fixes approximately 38 kg nitrogen in the soil (Rangasamy *et al.* 2001) from the atmosphere and thus adds to the nitrogen wherever it is grown. Hence, a successful selection programme have been undertaken to exploit genetic variability, heritability and genetic advance for different characters in 30 genotypes of urdbean.

MATERIALS AND METHODS

The experimental material comprised of 30 genotypes of blackgram, were maintained at the Division of Plant Breeding and Genetics, R.B.S. College, Bichpuri, Agra, in randomized block design with the spacing of 45 cm × 15 cm. The experiment was laid out with three replications. Agronomical practices were adopted as per the recommended package of practices during kharif 2000. Data were recorded on five randomly selected plants for each genotype in each replication for plant height (cm), days to 50% flowering, days to maturity, number of pods/plant, number of seeds/pod, pod length, 100 seed weight and seed yield/plant (g). The data recorded on above characters were subjected to statistical analysis. Components of variances (Burton, 1952), heritability (Burton and Devane, 1953) and genetic advance (Johnson *et al.*, 1958) were calculated.

RESULTS AND DISCUSSION

Variability determines the diversity percent among the genotypes. The data of mean performance and range (Table 1) revealed that considerable variability was present among the genotypes for all the characters under study.

Heritability, in broad sense is the ratio of genotypic variance to the phenotypic variance (Table 2). The heritability estimate of plant height (99.5%) was found maximum followed by yield/plant (96.6%), pod length (94.5%), number of pods/plant (90.5%) with minimum for days to flowering (65.0%) (Kasundra *et al.* 1996).

Genetic advance is the difference between mean of the progeny of selected individuals and the base population. The maximum genetic advance (Table 2) was obtained for number of pods/plant (31.47%) followed by plant height (30.85%), pod length (26.96%) and yield/plant (25.17%). Similar results were also reported by Ramprasad and Reddy (1989), Lakshmaian *et al.* (1990) and Ramprasad *et al.* (1991).

In the present investigation very high heritability coupled with high genetic advance was found for plant height followed by number of pods/plant and yield/plant. Thus selection for these character might be successful (Acharya *et al.* 1993 and Ram and Singh, 1993). The characters Days to maturity and number of seeds/plant

Table 1. Mean performance of urdbean genotypes

Characters	Range	Entires with	
		Lowest value	Highest value
Days to flowering	41.00 - 47.33	Tu - 99-6-1, 722, 723	717
Days to maturity	60.00 - 67.00	Tu - 99-66-1	KML-8, 703
Plant height (cm)	35.47 - 61.13	723	KML-8
Number of pods/plant	44.07 - 75.07	Tu - 98-10-5	BDU-4
Numebr of seeds/plant	5.27 - 6.60	447 - 2	Tu - 98-40-2
Pod length	2.37 - 4.57	717	547-22-12
100 seed weight	4.34 - 5.82	547-22-12	225
Yield/plant (g)	14.02 - 22.33	Tu - 99-843	BDU-4

Table 2. Genetic parameters for eight yield contributing traits in urdbean genotypes

Characters	Grand mean	Coefficient of genotypic variation	Heritability (%)	Genetic advance in percentage of mean
Days to flowering	43.83	3.38	65.0	5.61
Days to maturity	63.22	3.21	77.5	5.83
Plant height (cm)	46.02	15.01	99.5	30.85
Number of pods/plant	55.98	16.05	90.5	31.47
Numebr of seeds/plant	6.05	6.10	74.2	10.89
Pod length	3.59	13.49	94.5	26.96
100 seed weight	5.26	7.10	74.4	12.53
Yield/plant (g)	17.75	12.73	96.6	25.17

exhibited high heritability coupled with moderate genetic advance and medium variability, which indicated that additive gene action in the population might be encouraging. High heritability had been found associated with low genetic advance and low variability for the character days to 50% flowering which indicates that non additive gene action is responsible for

character and high heritability is exhibited due to influence of environment rather than genotypes and selected for such trait may not be rewarding. Thus, plant height followed by number of pods/plant and grain yield/plant may be given due weightage during selection programme for crop improvement.

REFERENCES

- Acharya, S., Gupta, S.K. and Jaiswal, B.S. 1993. *Indian Pulse Res.*, 6(2) : 198.
- Burton, G.W. 1952. Proc. 6th Intern. Grassland Congress, 1 : 227.
- Burton, G.W. and Devane, E.W. 1993. *Agron J.* 15 : 478.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1995. *Agron. J.*, 47 : 477.
- Kasundra, J.K., Pethani, K.V. and Kathira, K.B., 1996. *Indian J. Pulse Res.*, 8(2) : 113.
- Lakshmnaiah, K., Babu, P.R., Reddy, D.L., 1999. *Journal of Research, APAU*, 17(1) : 49.
- Ramprasad, P.V.S., Reddy, P.N., Reddy, K.r., 1991. *Journal of Pulse Res., APAU*, 17(1) : 60.
- Ram, T. and Singh, S. 1993. *Indian J. Pub. Res.*, 6(2) : 194.
- Rangasamy, P., Ushakumari, U., and Michael Gomez, S., 2001. *Int. J. Mendal*, 18(3) : 79.

PHYSICO-CHEMICAL PROPERTIES OF SOIL AND GRAIN YIELD OF RICE (*ORYZA SATIVA*) AS INFLUENCED BY ORGANIC AND INORGANIC SOURCES OF NUTRIENTS

S.S. PARIHAR*

TCB, College of Agriculture and Research Station
Indira Gandhi Agricultural University, Bilaspur-495001

ABSTRACT

A field experiment was conducted to study the changes in physico-chemical properties of soil after rice harvest and grain yield due to organic sources of nutrients along with chemical fertilizers. The average data showed that soil incorporation of crop residues like rice and wheat straw and farmyard manure (FYM) decreased the bulk density, increased the hydraulic conductivity, organic carbon and water holding capacity of soil at the end of the study than the initial values. Incorporation of organic materials increased the nutrient status of soil than no crop residues or FYM. Similarly, chemical fertilizers also influenced the physico-chemical properties of soil than no fertilizers, but there was no significant variation between 75% and 100% NPK recommended. Amongst the organic sources of nutrients, FYM incorporation gave significantly higher grain yield but comparable to other organic sources of nutrients. Application of 100% NPK recommended gave the highest yield (5293 kg/ha) which was at par with 75% NPK recommended, but both were significantly higher than 50% NPK and control. Interaction effect between organic and inorganic sources of nutrient was significant and 100% NPK recommended along with FYM @ 5 t/ha gave the highest yield (5610 kg/ha) followed by 100% NPK + wheat straw @ 5 t/ha. Total NPK uptake was significantly higher due to addition of nutrients (crop residues or FYM or fertilizers) than without addition of nutrients.

Key words : Bulk density, infiltration rate, rice straw, wheat straw, nutrient uptake, grain yield.

Inorganic fertilizers have a major role in intensive cropping system, which brought about commendable increase in crop production. However, with the progressive increase in the use of inorganic fertilizers alone in an unbalanced manner created adverse effect on soil health. The importance of organic sources of nutrients for crop production is realized not only in refurbishing soil productivity but also increasing the efficiency of inorganic fertilizers.

Use of organic materials along with chemical fertilizers into soil leads to increase in crop productivity and also sustained soil health for longer period. Application of organic sources can help in reducing the deleterious effect of continuous use of fertilizers on physico-chemical properties of soil (Singh *et al.*, 2000). Hence, an experiment was conducted to work out the effect of organic and inorganic sources of nutrients on

physico-chemical properties of soil at harvest and grain yield of rice.

MATERIALS AND METHODS

The experiment was conducted during rainy seasons of 1999 to 2001 at Research Farm, Bilaspur. The treatment consisted 4 sources or organic material viz., control, farmyard manure (5 t/ha), rice straw (5 t/ha) and wheat straw (5 t/ha) and 4 levels of NPK, viz., 0, 50, 75 and 100% recommended dose (100:50:30 NPK kg/ha). The experiment was laid out in randomized block design with three replications. Farmyard manure (FYM) and chopped crop residues were applied 10 days before rice planting. Rice variety 'Mahamaya' was transplanted during third week of July in all the years. The total rainfall during the crop seasons was 812, 785 and 927 mm in 1999, 2000 and 2001, respectively. Though the rainfall was well distributed, but at the later part of the crop seasons 4 irrigations were applied during all the years to maintain optimum soil

*Present address : Water Technology Centre, IARI, New Delhi-0110012.

moisture up to physiological maturity of the crop. Soil samples at the end of study and plant samples after harvesting were collected to analyze the physico-chemical of the soil and NPK content of grain and straw, respectively, following standard procedures.

RESULTS AND DISCUSSION

Physico-chemical properties of soil

Physical properties like bulk density, hydraulic conductivity and water holding capacity differed significantly, however, soil pH and electrical conductivity were not significantly influenced by incorporation of organic materials as well as chemical fertilizers at the end of the study (Table 1). It was observed that, incorporation of organic materials reduced the bulk density as compared to control. Addition of crop residues (rice or wheat straw) and FYM, and subsequent decomposition added organic matter to soil and thus per unit volume of soil reduced. Organic materials often found favourable in increasing the organic matter and decreasing bulk density of soil due to higher C : N ratio. Decrease in bulk density with the increase in organic carbon was also reported by Lanjwar *et al.* (2001) and Das *et al.* (2001).

Similarly, hydraulic conductivity of soil increased significantly due incorporation of crop residues and FYM over control. Generally, addition of organic materials in soil added organic matter, which creates favourable environment for increasing hydraulic conductivity. Mishra and Sharma (1997) also reported the similar results. Incorporation of crop residues and FYM decreased the bulk density and increased the soil porosity, and thus increased water holding capacity of soil. Organic substances having high C : N ratio are known to improve the soil physical and chemical properties of the soil.

In general, there was a positive improvement in fertility status of soil due to crop residues and FYM incorporation (Table 1). The available N, P₂O₅ and K₂O content of soil varied significantly due to application of chemical fertilizers and incorporation of organic materials, except under control and 50% NPK recommended. However, there was no significant difference between crop residues and FYM incorporation as well as between 75% and 100% NPK recommended (Table 1).

Effect on grain yield

Incorporation of crop residues and FYM

Table 1. Physico-chemical properties of soil after rice harvest as affected by sources of nutrients (at the end of study)

Treatments	Bulk Density g/cc	Organic carbon %	HC cm/hr.	MWHC %	Available kg/ha		
					N	P	K
Organic source							
Control	1.41	0.45	0.64	40.82	250.65	10.42	384.10
FYM@5t/ha	1.38	0.48	0.73	43.12	256.12	12.86	414.25
Rice straw @ 5t/ha	1.36	0.47	0.71	42.65	257.34	13.00	416.60
Wheat straw@5t/ha	1.36	0.48	0.73	43.00	256.65	13.30	419.00
C.D. at 5%	0.03	0.02	0.06	1.12	3.10	1.24	10.22
Inorganic source							
Control	1.40	0.46	0.65	40.65	251.10	10.80	382.22
50% NPK	1.40	0.46	0.46	42.15	252.00	11.65	396.30
75% NPK	1.37	0.48	0.75	42.80	257.15	12.82	424.25
100% NPK	1.35	0.49	0.76	43.65	260.95	14.02	429.16
C.D. at 5%	0.03	0.02	0.06	1.12	3.10	1.24	10.22
Initial value	1.42	0.46	0.62	39.65	253.00	12.00	412.33

HC - Hydraulic conductivity.

MWHC - Maximum water holding capacity.

increased the grain yield of rice significantly over control (Table 2). However, yields obtained under different organic materials were at par. Addition of crop residues and FYM had a favourable effect on over all soil health and fertility status and, therefore, increase in yield attributing characters and grain yield of rice (Tables 1 & 2). Organic materials having high C : N ratio improves the physical properties of soil by adding carbon into the soil. Similar observations were reported by Das *et al.* (2001) and Yadav and Kumar (1993). Organic materials after decomposition releases nutrients into soil slowly throughout the growth period resulting in better plant growth and development (Channabasavanna *et al.*, 2001). Application of chemical fertilizers also had significant effect on yield and yield attributes of rice. It was found that 100% NPK recommended gave significantly higher grain yield followed by 75% NPK. Balanced application of nutrients is known to ensure optimum supply of various soil nutrients and thus increased vegetative growth resulting in higher photosynthetic area and thereby higher translocation of photosynthates towards sink as compared to no nutrients. Similar results were reported by Singh *et al.* (2000) and Bandopadhyay and Puste (2002).

There was significant interaction between organic and inorganic sources of nutrients (Table

3). It was found that 100% NPK recommended and organic sources (crop residues of FYM) @ 5 t/ha gave on par with 75% NPK with organic sources but significantly higher than other combinations (Table 4).

Nutrient content and uptake

There was significant effect of sources of nutrients (organic and inorganic) on NPK content of grain and straw (Table 4). It was found that NPK content in grain and straw was significantly higher due to incorporation of crop residues and FYM and application of recommended fertilizers over control except N and P in straw. Similarly, there was no significant difference in NPK content of grain and straw under different organic sources and between 75% and 100% NPK recommended. Similar trend was also noticed for total uptake of NPK (Table 4). The highest removal of NPK was found with rice straw at par with other two organic sources of nutrients, but significantly superior over control. Application of 100% NPK recommended recorded highest uptake followed by 75%. However, these treatments produced significantly higher uptake of NPK than 50% and control. Since, total biomass was more with these treatments, total uptake was increased as compared to without organic or inorganic sources of nutrients (Table 4).

Table 2. Yield and yield attributes of rice as influenced by sources of nutrients (mean of 3 years)

Treatments	Effective tillers/m ²	Spikelets/panicle	1000-grain weight, g	Grain yield, kg/ha	Straw yield, kg/ha
Organic source					
Control	219.32	104.2	26.0	3663	4925
FYM@5t/ha	255.15	110.2	27.2	4767	5462
Rice straw @ 5t/ha	252.60	110.0	27.5	4678	5615
Wheat straw@5t/ha	249.40	112.4	28.0	4679	5430
C.D. at 5%	9.54	5.2	0.9	373	415
Inorganic source					
Control	213.00	102.4	26.1	3368	4705
50% NPK	239.10	110.2	26.9	4113	5110
75% NPK	258.32	112.0	27.6	4898	5716
100% NPK	264.44	112.2	28.2	5293	5924
C.D. at 5%	9.54	5.2	0.9	373	415

HC - Hydraulic conductivity.

MWHC - Maximum water holding capacity.

Table 3. Interaction effect of organic and inorganic sources of nutrients on grain yield of rice (mean of 3 years)

Treatments	Recommended NPK, %				
	0	50	75	100	Mean
Organic source					
Control	2715	3365	3910	4665	3663
FYM@5t/ha	3662	4412	5363	5610	4767
Rice straw @ 5t/ha	3605	4405	5198	5498	4678
Wheat straw@5t/ha	3590	4370	5222	5500	4669
Mean	3368	4113	4898	5293	-
C.D. at 5%			513		

Table 4. Nutrient content (%) and uptake (kg/ha) in rice as influenced by sources of nutrients (mean of 3 years)

Treatments	N content		P content		K content		Total uptake		
	Grain	Straw	Grain	Straw	Grain	Straw	N	P	K
Organic source									
Control	1.36	0.52	0.24	0.06	0.31	1.46	75.43	11.74	83.25
FYM@5t/ha	1.39	0.52	0.27	0.07	0.41	1.49	94.66	16.69	100.92
Rice straw @ 5t/ha	1.41	0.51	0.28	0.08	0.42	1.51	94.59	17.57	104.43
Wheat straw@5t/ha	1.40	0.51	0.28	0.07	0.43	1.50	93.20	16.90	101.57
C.D. at 5%	0.36	NS	0.04	NS	0.04	0.05	8.77	3.13	9.73
Inorganic source									
Control	1.34	0.51	0.24	0.05	0.37	1.44	69.12	10.43	80.21
50% NPK	1.38	0.52	0.26	0.05	0.42	1.50	83.33	13.25	93.92
75% NPK	1.40	0.52	0.28	0.08	0.43	1.52	98.29	18.28	107.94
100% NPK	1.43	0.54	0.29	0.08	0.42	1.51	107.68	20.09	111.68
C.D. at 5%	0.36	0.02	0.04	0.03	0.04	0.05	8.77	3.13	9.73

REFERENCES

- Bandopadhyay, A. and Puste, A.M. 2002. Effect of integrated nutrient management on productivity and residual soil fertility status under different rice (*Oryza sativa*) - pulse cropping system in rainfed lateritic belts of West Bengal. *Indian J. Agron.*, **47** : 33-40.
- Channabasavanna, A.S., Itnal, C.J. and Patel, S.G. 2001. Productivity, economic analysis and changes in physico-chemical properties of soil as influenced by integrated rice (*Oryza sativa*)- based cropping system. *Indian J. Agron.*, **47** : 1-5.
- Das, K., Medhi, D.N. and Guha, B. 2001. Recycling effect of crop residues with chemical fertilizers on physico-chemical properties of soil and rice (*Oryza sativa*) yield. *Indian J. Agron.*, **46** : 648-653.
- Das, K., Medhi, D.N. and Guha, B. 2003. Application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (*Oryza sativa*) - wheat (*Triticum aestivum*) system. *Indian J. Agron.*, **48** : 8-11.
- Lanjewar, M.M., Shelke, D.K. and Himase, B.J. 1992. Studies on effect of incorporation of rice straw in soil on its properties, rice yield and its residual effect on succeeding chickpea. *Journal of Soils and Crops*, **2** : 52-55.
- Singh, A.K., Angira, L.P. and Sharma, S.K. 2000. Root characteristics, soil physical properties and yield of rice as influenced by integrated nutrient management in rice wheat system. *Indian J. Agron.*, **45** : 217-222.
- Yadav, D.S. and Kumar, A. 1993. System based integrated nutrient management for sustainable crop system in Uttar Pradesh. *Fertilizer News*, **38** : 45-49.

GENETIC COMPONENTS OF VARIATION OF PHYSIOLOGICAL ATTRIBUTES FOR
DROUGHT SCREENING OF GENOTYPES IN AMERICAN COTTON
(*GOSSYPIUM HIRSUTUM* L.)

A. NARISI REDDY AND S. RATNA KUMARI

Acharya N.G. Ranga Agricultural University
Regional Agricultural Research Station, Lam, Guntur-522034, Andhra Pradesh

ABSTRACT

Thirty nine genotypes of American cotton (*Gossypium hirsutum* L.) were evaluated for estimating the genetic variability, heritability and genetic advance as per cent of mean for yield and yield components besides drought tolerance parameters. The estimates of GCV and PCV were high for number of bolls per plant and seed cotton yield. The drought tolerance parameters specific leaf area and specific leaf weight also showed considerable variation. The PCV was greater than GCV. The GCV/PCV ratio was high for specific leaf area and specific leaf weight indicating that these traits were not much influence by the environment. Heritability estimates were high for specific leaf area, specific leaf weight, relative water content and boll weight indicating the amenability in the selection process. High heritability coupled with high genetic advance was observed for specific leaf area, specific leaf weight and boll weight indicating the operation of additive gene action thereby indicating the amenability of these traits in selection process. Low heritability as well as low genetic advance was manifested for the character chlorophyll stability index, suggesting the involvement of non-additive gene action in the inheritance of this trait.

Key words : Genetic variability, cotton , additive gene action, non-additive gene action.

Cotton (*Gossypium hirsutum* L.) is an important commercial crop grown in Andhra Pradesh in an area of 10.02 lakh hectares producing 26.75 lakh bales with a productivity of 458 kg/ha. The productivity in Andhra Pradesh is gradually declining due to various biotic and abiotic stresses. In order to develop more efficient genotypes for high seed cotton yield coupled with tolerance to drought in cotton, requires thorough understanding of physiological and yield component traits which directly or indirectly influences the yield. If physiological traits responsible for drought tolerance could be identified as contributing significantly to yield, they could prove as alternative selection criteria in yield improvement programme. Information on the magnitude of genetic variability for the desirable physiological traits of this crop is of great value to the plant breeders. Superior genotypes can be isolated by selection, if considerable genetic variation exists in the population. Besides genetic variability, heritability and genetic advance also

play a vital role for the improvement (genetic gain) of any character. Very little information is available, particularly on physiological traits that are contributing towards drought tolerance. Keeping in view, the present investigation was carried out to find out the magnitude of variability, heritability and genetic advance mainly for physiological traits besides yield and yield components in cotton.

MATERIALS AND METHODS

Thirtynine genotypes of cotton were grown in a randomized block design with 2 replications during 1997-98 at Regional Agricultural Research Station, Lam. Each genotype was grown in a 4 row plot of 6 meter length with a spacing of 105 cm between rows and 60 cm within a row. Recommended agronomic and plant protection practices were adopted. Five plants at random were taken in each plot and data on days to 50% flowering, specific leaf area (cm²/g), specific leaf weight (mg/cm²), relative water content (%), chlorophyll stability index, plant height (cm),

number of sympodia per plant, number of bolls per plant, boll weight (g) and seed cotton yield (q/ha) were recorded. The mean data of five plants were used for statistical analysis. The analysis of variance was carried out following Panse and Sukhatme (1978). Phenotypic and Genotypic components of variance were estimated according to Burton (1952). Heritability in broad sense and Genetic Advance as per cent of mean were worked out using the formula given by Allard (1960).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the varieties for all the characters studied. The estimates of mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as percent of mean (GAM) are presented in Table 1.

A wide range of variation was recorded for specific leaf area, specific leaf weight, number of bolls per plant and seed cotton yield. The phenotypic coefficient of variation ranged from 5.47% for days to 50% flowering to 44.59 for number of bolls per plant and the corresponding values for genotypic coefficients of variation were 3.76% and 33.56%, respectively. Number of bolls per plant showed highest coefficients (both genotypic and phenotypic) of variation (44.59 and 35.56%) indicating greater diversity among the genotypes for this traits. Seed cotton yield also showed relatively high coefficients (36.62 and 30.91%) of variation. Similar results were reported by Sankarpandian *et al.*, (1998), Valarmathi and Jehangir (1998), Ahuja and Tuteja (2002) and Rao and Reddy (2001). Considerable variation was also observed for the physiological traits responsible for drought tolerance viz., specific leaf area (14.99 and 13.55%) and specific leaf weight (16.02 and 15.49%) indicating the greater scope for further improvement through selection, especially when the objective is to isolate genotypes specifically suitable for rainfed situations. In general the differences between GCV and PCV were low for majority of the traits indicating that these traits were not much influenced by the environment, thus suggesting ample scope for improvement through selection.

The GCV/PCV ratio was high for specific leaf weight, relative water content and boll weight indicating that these traits were not much influenced by the environment, thus suggesting ample scope for improvement through selection. The GCV/PCV ratio was high for specific leaf weight, relative water content and boll weight indicating that these traits were not much influenced by the environment. Low values of genotypic and phenotypic coefficients of variation were observed for days to 50% flowering, relative water content and chlorophyll stability index indicating the narrow range of variability for these traits thereby restricting the scope for selection. Sumathi and Nadarajan (1996) reported narrow range of variability for days to 50% flowering. These results indicated that there is ample scope for improving these traits by practicing simple selection as considerable amount of variation is present in the material.

Heritability estimate was found to be highest for specific leaf weight (93.5) and lowest for days to 50% flowering (47.2). High estimates of heritability indicates the amenability of the traits in selection process. Specific leaf area (81.8), relative water content (85.3), plant height (75.1) and seed cotton yield (71.3) also showed relatively high estimates of heritability, while chlorophyll stability index (47.3) showed low heritability estimates. The heritability estimates obtained in the present study should be considered maximum since it includes dominance, epistasis as well as additive genetic variance. High heritability and high genetic advance are crucial for the improvement (genetic gain) of any character. The characters specific leaf area, specific leaf weight and boll weight which showed high heritability also showed high genetic advance. Similar results were reported by Valarmathi and Jehangir (1998) and Rao and Reddy (2001) for boll weight in their studies. High heritability coupled with high genetic advance showed that these characters are governed by additive gene action. The expected genetic advance would be low when the heritability is mainly due to non-additive gene effect but the genetic advance would be high when the heritability is due to additive gene

Table 1. Estimates of mean, range, variability, heritability and genetic advance as percent of mean for yield, yield components and physiological traits

Characters	Mean	Range	PCV	GCV	GCV/PCV	h^2	GAM
Days to 50% flowering	53.57	48.50-58.00	5.47	3.76	0.69	47.2	5.33
Specific leaf area (cm ² /g)	118.33	75.50-149.60	14.99	13.55	0.90	81.8	25.53
Specific leaf weight (mg/cm ²)	8.78	6.68-12.63	16.02	15.49	0.97	93.5	30.88
Relative water content (%)	76.96	67.59-88.58	7.92	7.32	0.92	85.3	13.92
Chlorophyll stability index (%)	84.88	76.03-94.20	7.13	4.90	0.69	47.3	6.94
Plant height (cm)	126.90	80.00-162.50	16.03	13.89	0.87	75.1	24.79
Number of sympodia per plant	18.11	11.00-25.00	20.29	14.80	0.73	53.2	22.24
No. of bolls per plant	27.83	9.85-49.60	44.59	35.56	0.80	63.6	58.44
Boll weight (g)	3.96	2.94-5.53	14.04	13.55	0.96	93.2	26.93
Seed cotton yield (q/ha)	17.51	8.86-28.37	36.62	30.91	0.84	71.3	53.74

effect (Panse, 1957). This provides scope for further genetic improvement through selection. The drought tolerance parameters viz., specific leaf area and specific leaf weight which showed high heritability estimates also recorded high genetic advance indicating the operation of additive gene action for these traits. Low heritability as well as low genetic advance was manifested for the character chlorophyll stability index, suggesting the involvement of nonadditive gene action in the inheritance of this trait. Further improvement in this trait can be

brought forth through heterosis breeding.

When the variability, heritability and genetic advance are considered together, specific leaf area and specific leaf weight may be the best reliable drought tolerant parameters in American cotton that could be exploited through hybridization and selection for improvement, since these characters recorded high variability, heritability and genetic advance as percent of mean for developing high yielding cotton varieties/hybrids possessing drought tolerance.

REFERENCES

- Ahuja, S.L. and Tuteja, O.P. 2000. Variability and association analysis for chemical components imparting resistance to *Gossypium hirsutum* cotton. *J. Cot. Res. Deve.*, **14**(1): 19-22.
- Allard, R.W. 1960. Principles of Plant Breeding. John Wiley and Sons Inc. New York. pp. 485.
- Burton, G.W. 1952. Quantitative inheritance in grasses. Proceedings of the sixth International Genetics Congress: pp. 277-283.
- Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet.*, **17**: 318-28.
- Panse, V.G. and Sukhatme. 1978. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.
- Rao, G.N. and Reddy, M.S.S. 2001. Studies on heritability and variability for yield and its components in *hirsutum* cottons. *J. Cot. Res. Deve.* **15**(1): 84-86.
- Sankarapandian, R., Krishnadoss, D., Muppudathi, N. and Ananda Kumar, C.R. 1998. Genetic variability over environments and stability analysis of rainfed cotton (*G. hirsutum* L.). *J. Indian Soc. Cot. Improv.*, **23**(2): 144-146.
- Sumathi, P. and Nadarajan, N. 1996. Genetic variability in cotton. *J. Indian Soc. Cot. Improv.*, **21**(1): 33-36.
- Valarmathi, M. and Jehangir, K.S. 1998. Studies on genetic parameters for yield and fibre quality traits in intra-varietal crosses of cotton (*G. hirsutum* L.). *J. Indian Soc. Cot. Improv.*, **23**(1): 64-67.

STUDIES ON FERTIGATION OF MANGO CV. AMRAPALI

S.K. THAKUR AND PRABHAKAR SINGH

*Department of Horticulture
Indira Gandhi Agricultural University, Raipur (CG)*

ABSTRACT

An experiment was carried out to evaluate the effect of fertigation on growth, yield and quality attributes of mango cv. Amrapali. The highest number of fruits per plant and total yield per plant were recorded under T₄ with application of 75% of recommended dose through fertigation. The application of 100% of recommended dose through fertigation recorded maximum fruit weight, pulp weight, length and breadth of fruit. However, the minimum stone and peel weight were recorded under the same treatment. In respect of qualitative characters, the highest total soluble solids and reducing sugar were recorded under T₅ (100% of RDF). The maximum acidity was observed under control (surface irrigation + recommended dose) and minimum was recorded under T₃ (50% of RDF).

Key words : Fertigation, mango.

Mango is one of the oldest and choicest fruit of India referred as "king of fruits" for its high quality palatability tempting aroma and flavor. Nutrition of fruit trees is an important part of orchard management practices. Essential of fruit trees is an important part of orchard management practices. Essential nutrients have a certain specific role to play in the plant and their presence is a must for a plant to complete its life cycle and to determine the fruitfulness with physico-chemical properties of the fruits. The fertilizers are becoming costly input day by day. Hence, it is felt necessary to study the efficient use of this input. This can be achieved by adopting efficient use of drip system of fertigation.

Keeping this in view the present study was taken up to the enhancing fruit yield and quality to mango through fertigation.

MATERIALS AND METHODS

The present investigation to study the effect of fertigation on growth Yield and quality was carried out ten-year old mango hybrid, Amrapali in vertisols. A field experiment was carried out at Horticulture research farm IGAU Raipur during 2002-2003. The experiment was laid out in randomized block design with three

replications each comprising of 6 treatments such as-

T₁ = Surface irrigation + Recommended dose of fertilizer (control) (NPK, 800, 440 and 1440g, respectively)

T₂ = Drip irrigation + Recommended dose of fertilizer

T₃ = 50% of RD through fertigation (RDF)

T₄ = 75% of RD through fertigation (RDF)

T₅ = 100% of RD through fertigation (RDF)

T₆ = 125% of RD through fertigation (RDF)

Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muriate of potash, respectively for T₁ and T₂ as worked out for each plot. The fertilizer for the treatment T₁ and T₂ were applied by ring method. Fertilizer for treatment T₃ and T₆ were applied through drip irrigation system in alternate day. Weighed quantity of water-soluble fertilizer, urea and muriate of potash as per scheduled was added in water and then injected through the lateral lines as per treatment. In conventional method (T₂ and T₂), full quality of nitrogen and half quality of phosphorus and potash were applied just before the first irrigation and the remaining quality of

phosphorus and potash were applied with the last irrigation in the month of October.

The observations were recorded on, plant height, plant spread, physical characters of fruit and fruit yield. The observation on quality of fruits in terms of total soluble solids, acidity, ascorbic acid and reducing sugar were recorded.

The biometrical observations like number of pods, number of pods, number of nodules and dry weight of nodules, grain weight, shell weight, per plant and 100 seed weight and grain yield, straw yield and biological yield were recorded.

RESULTS AND DISCUSSION

Fruit characters - Data regarding number of fruit per plant, yield per plant (kg), fruit weight (g), stone weight (g), pulp weight (g), length and breadth of fruit (cm) of Amrapali variety of mango are presented in Table 1. Average number of fruits per plant was recorded highest (173.66) under treatment (T₄) with application of 75% of recommended dose through fertigation followed by 100% of recommended dose through fertigation (T₅) as compared to T₁ (control). This was in agreement with the result of Sahu (2002), in pomegranate. The highest yield (36.77 kg/plant) was recorded under T₄ followed by T₅ (36.62 kg/plant) and same was also supported by Venkatesh Murthy (1997) and Colapietra (1987) in grapes. Similar results were also reported by Idate *et al.* (2001) in pomegranate cv. Mridula.

The highest fruit weight (212.250 g), and pulp weight (147.75g), were recorded under T₅ with the application of 100% recommended dose through fertigation followed by 75% of recommended dose through fertigation (T₄). These observations were also in conformity with those of Bruce *et al.* (1980). They recorded heavier bunches under fertigation. These observations were also in conformity with those of Bruce *et al.* (1980). They recorded heavier bunches under fertigation.

Qualitative characters of fruits

Data regarding total soluble solids, acidity, reducing sugar per cent and ascorbic acid (mg/

Table 1. Effect of fertigation on growth and yield of mango cv. Amrapali

Treatments	Plant height (m)	Plant spread (m)	Fruit length (cm)	Fruit breadth (cm)	No. of fruits/plant	Yield/plant (kg)	Fruit weight (g)	Stone weight (g)	Peel weight (g)	Pulp weight (g)
T ₁	4.197	4.390	4.223	EE	120.30	22.00	182.870	40.75	33.47	108.65
T ₂	4.100	4.557	4.450	5.420	120.64	24.20	200.587	38.95	33.40	128.11
T ₃	4.217	4.570	4.317	5.600	130.55	25.88	198.230	38.45	3.36	126.42
T ₄	4.453	4.697	4.970	5.617	173.66	36.77	211.730	35.20	30.30	146.23
T ₅	4.250	4.593	5.133	5.703	172.53	36.62	212.250	34.25	30.25	147.75
T ₆	4.390	4.627	4.820	6.417	160.31	33.08	206.350	36.77	31.97	137.61
SE m±	0.159	0.131	0.384	5.810	0.608	0.444	0.711	0.839	0.440	1.163
C.D. at 5%	NS	NS	NS	0.018	1.92	1.40	2.24	2.64	1.39	3.67

BE = Beginning of the experiment.

EE = Ending of the experiment.

Table 2. Effect of fertigation on fruit quality of mango cv. Amrapali

Treatments	Total soluble solids	Acidity	Reducing sugar	Ascorbic acid (mg/100g)
T ₁	*26.12**(19.40)	*3.358**(0.343)	*14.484**(6.26)	35.853
T ₂	26.76 (20.30)	3.085 (0.292)	14.484 (6.26)	37.000
T ₃	26.80 (20.35)	0.996 (0.271)	14.590 (6.35)	37.277
T ₄	27.06 (20.71)	3.050 (0.284)	14.601 (6.36)	36.830
T ₅	27.43 (21.25)	3.241 (0.322)	14.718 (6.46)	36.373
T ₆	27.05 (20.70)	3.155 (0.302)	14.707 (6.45)	36.210
SE m±	0.101	0.029	0.015	0.678
C.D. at 5%	0.32	0.09	0.05	NS

* Mean arcsine transformed value.

**Untransformed value, in per cent unit, of the corresponding mean arcsine transformed value.

100g) of mango fruits are presented in Table 2.

The maximum transformed total soluble solids and reducing sugar (27.43 and 14.718 respectively) were recorded T₅ (100% of recommended dose through fertigation) and lowest (26.12 and 14.484) were recorded under control (T₁). The present findings are on line with those reported by Leilsen *et al.* (1987) in grape and Koo (1984). In the present findings

the T₁ (Surface irrigation + Recommended dose) recorded maximum transformed acidity (3.358) and the minimum transformed acidity was recorded under T₃ (50% of RDF). The present results are also more or less similar to those reported by Koo (1984) in grape. Koo (1984) observed that fertigation increased the total soluble solids and decreases the acidity than plant receiving solid fertilizers.

REFERENCES

- Bruce, R.R., Chesness, J.L., Keisting, T.C. and Patlas, J.E. 1980 Irrigation of crop in the South Eastern State. Principle and practices, USDA-SEA Manual ARMS-9.
- Colapietra, M. 1987. The effect of the increasing rates of plant nutrients on the qualitative yield of grape vines. A comparison of fertigation and manually applied fertilizer. *Rivista di viticoltura e di enologia*, 40(6) : 223-249.
- Idate, G.M., Chaudhari, S.M. and More, T.A. 2001. Fertigation in pomegranate (*Punica granatum* L.) *Production system of Horticultural crops*, 49 : 69-70.
- Koo, R.C.J. 1984. The important of ground coverage by fertigation of citrus on sandy soils, *J. fertilizer issue.*, 1(2) : 75-78.
- Nelson, H.G., Stevenson, D.S. and Gehringer, A. 1987. The effect of NPK fertilization on element uptake, yield and fruit composition of foeh. Grapes in British Colombia. *Canadian J. Plant Sci.*, 67(2) : 511-520.
- Sahu, K.K. 2002. Effect of fertigation on growth, yield and quality of pomegranate (*Punica granatum* L.) CV. Ganesh, M.Sc. (Ag.) Thesis, IGAU, Raipur (C.G.).
- Venkatesh Murthy, P. 1997. Studies on fertigation in Benglure blue grapes : comparision of sources and level of nutrient. Ph. D. thesis. Univ. Agril. Sci. Bangalore.

VARIATION OF DTPA-EXTRACTABLE MICRONUTRIENTS WITH SOIL PROPERTIES IN SEMI-ARID PART OF NORTHERN MARATHWADA IN MAHARASHTRA

G.U. MALEWAR*, A.L. DHAMAK AND SYED ISMAIL

*Department of Agricultural Chemistry and Soil Science
Marathwada Agricultural University, Parbhani, Maharashtra-431 402*

ABSTRACT

One hundred and three surface soil samples (0-0.20m) from sugarcane and sweet orange growing soils of semi-arid part of northern Marathwada region of Maharashtra were studied for distribution of micronutrients and their relationships with some soil properties. Differential contents of micronutrients were observed in various soil groups. Typic Haplusterts showed relatively high potential for supply of DTPA-zinc, iron, manganese and copper as compared to other soil groups by virtue of higher clay contents, Lithic Ustorthents were more prone to the deficiencies of micronutrients by virtue of lower clay and organic carbon contents. On the basis of soil critical limits for micronutrients, 88.7 and 18.4 per cent soils were rated as deficient in Fe and Zn, respectively. DTPA-extractable Fe, Zn, Cu and Mn were positively and significantly correlated with organic carbon and clay content. However, pH, EC and CaCO_3 were negatively and significantly correlated with DTPA-extractable micronutrients. Widespread deficiency of Fe followed by Zn might pose nutritional problems in sugarcane and sweet orange production in the area.

Key words : DTPA, soil, Maharashtra, availability of micronutrient.

Deficiencies of micronutrients are widespread in Indian soils. This is mainly attributed to progressive depletion of these micronutrients as a result of intensive cultivation through introduction of high yielding varieties, considerable decrease in recycling of crop residues and animal manures, use of marginal and problem soils for crop production and interplay of antagonistic nutrient interactions (Malewar and Sayed Ismail, 1995). After availability of canal water from Jayakwadi irrigation project in this area, the average productivity of crops in general and sugarcane and sweet orange in particular was increased to higher potential. However, the average productivity of both the cash crops declined tremendously year after year (DASM, 1997-95; Patil and Malewar, 1998). It is suspected that the decline in yield levels of very important cash crops of this area may be due to deficiencies of cluster of micronutrients and other soil related constraints. Thus, it was felt necessary to assess the micronutrient availability in relation to soil

properties.

MATERIALS AND METHODS

One hundred and three representative surface soil samples (0-0.20m depth) were collected from sugarcane and sweet orange plantation of Jayakwadi command area comprising Jalna and Aurangabad districts under semiarid region of northern Marathwada during April 1999. On the basis of earlier soil survey and mapping work (Challa et al., 1995; Malewar, 1976; Anonymous, 1972). These soils were correlated and classified as per USDA classification system representing Typic Haplusterts (30). Typic Ustorthents (19). Lithic Ustorthents (16) and Vertic Haplustepts (30) (Sol Survey Staff, 1998). Standard methods were used for analysing some chemical properties (Jackson, 1973), while DTPA-extractable micronutrients were analysed by using the method enumerated by Lindsay and Norvell (1978).

RESULTS AND DISCUSSION

The results (Table 1) show that soil pH and electrical conductivity does not vary within the

*Present address : Baldhan, 4, Dadarao Layout, Sambhajinagar, Parbhani-431 401.

Table 1. Properties of the soil from semiarid area of northern Marathwada

Soil sub-group and (No. of samples)	pH	EC (dSm ⁻¹)	CaCO ₃ (g kg ⁻¹)	Clay (%)	Organic carbon (g kg ⁻¹)
Typic Haplusterts (30)	7.50-7.98	0.18-0.62 (0.33)	37.50-110.00 (63.70)	52.64-68.42 (59.42)	2.3-8.3 (5.7)
Vertic Haplustepts (38)	7.45-7.96	0.13-0.78 (0.37)	36.50-110.00 (66.60)	31.92-52.63 (39.82)	3.2-7.4 (5.5)
Typic Ustorthents (19)	7.40-7.96	0.12-0.69 (0.34)	46.00-99.00 (73.70)	25.30-43.76 (29.44)	2.5-8.3 (5.7)
Lithic Ustorthents (16)	7.42-8.00	0.18-0.42 (0.32)	38.50-114.00 (91.80)	17.58-31.64 (22.54)	0.9-5.8 (3.1)

Figures in parenthesis indicate average values.

different soil groups. However, clay, CaCO₃ and to some extent organic carbon indicated variation within the soil subgroups wherein highest average value of clay content with lowest CaCO₃ and lowest clay content with highest CaCO₃ was observed in Typic Haplusterts and Lithic Ustorthents, respectively. Higher clay content in Typic Haplusterts followed by Vertic Haplustepts appear to be more closely related to the basaltic alluvium parent material rich in aluminosilicates and alkaline earth from which these soils are derived (Challa *et al.*, 1995). Relatively more accumulation of CaCO₃ in Typic/Lithic Ustorthents may be partly associated with their recent origin with rich in alkali earth and partly due to calcification process prevalent in the semiarid region (Joshi, 2000). Slightly more accumulation of organic carbon in Vertisols may be ascribed to the existing crop/cropping systems in northern Marathwada (Malewar, 1995). Among the various groups, Typic Haplusterts showed considerably higher DTPA-Zn, Fe, Mn and Cu in soils having mean of 1.64, 2.48, 24.28 and 1.62 mg kg⁻¹, respectively (Table 2). Vertic Haplustepts (Soil Survey Staff, 1998) were next to Typic Haplusterts in the content of DTPA-Zn, Fe, Mn and Cu with average values of 1.38, 2.26, 23.68 and 1.39 mg kg⁻¹ soil, respectively. Geochemical point of view, basaltic parent material on which Vertisols and associated soils developed are rich in ferromagnesian minerals and constitute bulk of

iron ores (magnetite, limonite, ilmenite) followed by augite, olivine, pyroxene, hornblende and chlorite as heavy minerals and quartz, feldspar, calcite as light minerals (Maniyar *et al.*, 1981; Gaikwad *et al.*, 1974). Thus, these mineral rich soils in Fe, Mn, Zn and Cu reflected in their higher availability (Malewar and Randhawa, 1978). It may also be partly due to cropping system and type of manure used. Further, narrow variation in micronutrient supply in these two soils groups may be due to the differences in the content of montmorillonitic mineral in these soils (Deopal, 1998). Lithic Ustorthents and Typic Ustorthents were rather coarser and lighter soils containing lower amount of clay and, thus, low in micronutrient supply. These findings are in the lines of those reported by Yelvikar *et al.*, (1996). On the basis of soil threshold values of micronutrients, 88.7 and 18.4 per cent of the soil sample analysed were rated as low in iron and zinc, respectively (Table 2). In general the deficiency of iron was found widespread throughout the investigated area. But sporadic deficiency recorded in zinc and it was more prone to the soils having lower clay content (Ravikivitch, *et al.*, 1961).

It was also depicted that increasing contents of organic carbon and clay in soils resulted in increase in availability of DTPA extractable micronutrients indicated by higher 'r' values (Table 3). Availability of DTPA extractable

Table 2. DTPA extractable micronutrients in the soils of semi-arid area of northern Marathwada region

Soil sub-group and (No. of samples)	Fe (Mg kg ⁻¹)	No. of samples deficient and percent deficiency	Zn (Mg kg ⁻¹)	No. of samples deficient and percent deficiency	Cu (Mg kg ⁻¹)	Mn (Mg kg ⁻¹)
Typic Haplusterts (30)	1.08-4.94 (2.48)	25 (83.3)	0.42-3.84 (1.64)	3 (10)	0.32-4.00 (1.62)	8.94-36.28 (24.28)
Vertic Haplustepts (38)	0.82-4.98 (2.26)	34 (89.0)	0.32-2.84 (1.38)	6 (15.7)	0.42-4.54 (1.39)	12.34-35.80 (23.68)
Typic Ustorthents (19)	1.30-6.20 (2.42)	17 (89.0)	0.42-3.38 (1.25)	4 (21.0)	0.28-2.54 (1.15)	4.86-29.20 (22.74)
Lithic Ustorthents (16)	0.88-9.36 (2.40)	15 (93.7)	0.32-3.20 (1.17)	6 (37.5)	0.28-2.26 (0.86)	10.62-28.68 (17.98)

Figures in parenthesis indicate average values.

Table 3. Relationship between DTPA extractable micronutrients and soil properties ('r' values)

Variables	DTPA Fe	DTPA Zn	DTPA Cu	DTPA Mn
pH	-0.805**	-0.603**	-0.234*	-0.375**
EC	0.023	-0.337**	-0.191	-0.227*
CaCO ₃	-0.678**	-0.621**	0.368**	-0.537**
Organic Carbon	0.624**	0.700**	0.368**	0.402**
Clay	0.308**	0.514**	0.447**	0.402**

* and ** indicate significant at 5 and 1% level, respectively.

micronutrients in presence of higher content of organic carbon is due to chelation of these metallic cations with humic substances present in organic matter. Negative and significant correlation between micronutrients and pH and CaCO₃ were observed. At higher pH and CaCO₃ the soluble metallic cations precipitate chemically and in turn decrease their availability (Dhane and Shukla, 1995). Thus, availability of Zn, Mn and Cu are controlled by these soil properties developed under semiarid area of northern Marathwada region of Maharashtra. Higher pH more accumulation of CaCO₃ and low organic matter in soils lead to management constraints particularly in sugarcane and sweet orange plantation. High pH coupled with CaCO₃

accumulation influenced growth of sugarcane adversely with iron chlorosis to 3-4 month old plants on a large area of the region. This sickness is controlled by 2-3 foliar sprays (0.5% FeSO₄) at an interval of 10 days (Malewar, 1986). Soils high in CaCO₃, and low in organic matter exhibit typical symptomatology of zinc deficiency with detrimental effect of CaCO₃. However double or triple the recommended dose of organic manure plus 10 or 15 Zn kg⁻¹ soil improve growth and remove zinc deficiency in sweet orange (Patil, 1997). In nutshell, all the soil groups are well supplied with Mn and Cu while widespread deficiency in Fe followed by Zn, which might become limiting specifically for sugarcane and sweet orange production in this area.

REFERENCES

- Anonymous, 1972. A Report on Soil Survey of MAU farm, National Bureau of Soil Survey and Land Use Planning, Nagpur.
- Challa, O., Vadivelu, S. and Sehgal, J. 1995. NBSS Publ. 546. NBSS and LUP., Nagpur, 47 p.
- DAMS, 1997-98. District wise Agricultural Statistical Information of Maharashtra 1997-98 (Epitome) Part II.
- Deopal, H. 1998. *Ann. Agric. Res.*, **19** : 324.
- Dhane, S.S. and Shukla, L.M. 1995. *J. Indian Soc. Soil Sc.*, **43**, 597.
- Gaikwad, S.T., Rao, Y.S. and Verma, H.K.C. 1974. *J. Indian Soc. Soil Sc.*, **22**(2) : 181.
- Jackson, M.L. 1973. Soil Chemical Analysis, Prentice Hall of India, Pvt. Ltd., New Delhi.
- Joshi, DC. 2000. Nat. Symp. Gujarat Agricultural University, Junagadh, Ext. Sum. Vol. I. pp. 8-12.
- Lindsay, W.L. and Norvell, W.A. 1978. *Soil Sci., Soc. Amer. J.* **42**, 421.
- Malewar, G.U. 1976. *J. Maharashtra Agric. Univ.* **1**, 155.
- Malewar, G.U. 1986. An. Rep. Dept. Agricul. Chem. & Soil Sc., Marathwada Agril., Univ. Parbhani.
- Malewar, G.U. 1995. *J. Maharashtra Agric. Univ.* **20**(3) : 330.
- Malewar, G.U. and Randhawa, N.S. 1978. *J. Maharashtra Agric. Univ.* **3**, 157.
- Maniyar, V.G., Malewar, G.U. and Gaffar, S.A. 1981. *Curr. Agirc.* **2**(1-2) : 68.
- Patil V.D. 1997. Ph. D. thesis, Marathwada Agricultural University, Parbhani.
- Patil v.d. and Malewar G.U. 1998. *J. Indian Soc. Sci.*, **46** : 151.
- Ravikvitch, S. Margolin, M. and Novrot, J. 1961. *Soil Sci.*, **92** : 85.
- Soil Survey Staff. 1998. Keyw to Soil Taxonomy, Eighth Edition, SMSS Technical Monograph, 19, Virginia. USA.
- Yelvikar, N.V. Syed Ismail, Muneera Sddiqu, Malewar, G.U. and Tajuddin. 1996. *J. Indian Soc. Soil Sci.* **44** : 781.

INHERITANCE OF ROOT TRAITS ASSOCIATED WITH DROUGHT TOLERANCE IN MAIZE

MEENA KUMARI*, SAIN DASS, VIMALA Y. AND PAWAN ARORA

*CCS Haryana Agricultural University
Regional Research Station, Karnal-132001, Haryana*

ABSTRACT

Twelve maize inbred lines having different degree of drought tolerance were used for the development of 8×4 line-tester for conducting genetical studies w.r.t. various root parameters viz. vertical expansion (cm), horizontal expansion (inches) and root biomass (g). The analysis of variance for combining ability revealed that gca and sca variances were highly significant. The sca variances were predominant in comparison to gca variances for all the characters studied. This indicated that there is greater contribution of non-additive gene action in expression of these characters. L1 followed by L5 among lines and T4 (Tester) were proved to be good general combiner for most of the drought environment for the various root traits associated with drought tolerance. The good specific cross combinations involved parents of high × high and high × low general combiners.

Maize is predominantly rainfed crop. More than 85% of the crop area is affected by moisture stress. At the initial stages, no extensive efforts have been given to develop the various drought tolerance traits. Even till today the main efforts of the research are for irrigated area. To help the rainfed area, at least artificially created environments to get the desired results to stabilize the productivity under rainfed conditions. Drought tolerance is a complex character governed by the combination of several plant traits. So far, major emphasis in maize research has been on the development of hybrids or composites varieties under normal/well watered conditions. Therefore, in India no maize variety has been developed which is specifically possessing drought to tolerant traits. Also these areas have remained unexploited for the want of suitable varieties. While the demand for maize is increasing every year due to expansion of industrial sectors the area under irrigated conditions can not be increased. However, developing the drought tolerant varieties can stabilize the maize productivity.

To develop the drought tolerant lines efficient selection criteria/effective screening techniques are required to evaluate the drought

tolerant lines for getting the reproducible/dependable results. Therefore, the material was screened under artificially created drought stress environments to get the desired results.

MATERIALS AND METHODS

Different treatments of drought were given as below :

1. Irrigation limited at knee height stage, further irrigations as per schedule. (IR1)
2. Irrigation was limited at flowering stage, further irrigation released as per schedule. (IR2)
3. Irrigation limited at grain filling stage. (IR3)
4. Irrigation limited at both flowering and grain filling stage. (IR4)
5. No irrigation after knee height stage. (IR5)
6. In control all the irrigations required by the crop were given as per crop schedule. (WW)

Experiment was conducted both in field and in net-house conditions. All the trials were replicated thrice. Each genotype was grown in one row plot of 5 m length. Plant to plant and row to row distances were maintained 20 cm and 60 cm, respectively.

In the first crop season (Feb-1998) the material was evaluated in the field conditions and controlled water regimes were created. All the environments were distanced from each

*Correspondence address : DMR, IARI, New Delhi-110 012.

other by a buffer channel followed by bund and polythene sheets to check the seepage. Selected material was reevaluated under controlled water conditions (Feb-99, Kharif, 99) in the field and rain-sheltered cemented plots.

Ten competitive plants from each genotype were selected at random for recording observation in various quantitative traits.

RESULTS AND DISCUSSION

Root study was conducted for vertical and horizontal expansion along with root biomass for various genotypes including parents and hybrids in different artificially created drought environments and was compared with the control. The mean and range of all the three root traits and grain yield varied significantly in different environments (Table 2).

Vertical expansion (cm)

Invariably, it was observed that root length under severe stress was affected irrespective of hybrids and parents. The vertical expansion of root in hybrids was much better than the parental lines under well-watered conditions. Hybrids L1 × T2, L1 × T3, L2 × T3, L3 × T4, L4 × T2, L5 × T1, L5 × T4, L7 × T1, L7 × T4, L8 × T1 and L8 × T2 showed better vertical expansion of roots under different stress conditions. Lines L1, L2 and L7 and testers T2 and T3 were desirable for root length in stress conditions. Fischer, Johnson and Edmeades, 1985 viewed that in areas, where plant population is sufficient, there at particular crop growth stage, the genotypes have the ability to go as deep as they can, for their survival.

Horizontal expansion (inches)

Great variation was observed for horizontal

expansion of roots in varied drought environments (Table 3). However, the decrease in horizontal expansion of roots in inbreds was more in different stress environments than the hybrids. L1, L6, L7 (lines), T3 (Tester) and L2 × T3, L5 × T4, L1 × T4 and L5 × T1 (crosses) were the desirable genotypes for better horizontal expansion of roots under severe stress environments. Deep roots of unwatered plants executed very high soil water depletion rates/unit length with holding water greatly restricted root proliferation in upper part of soil profile, but resulted in deeper penetration & higher soil water depletion rates to greater depths. (Sharp and Davies, 1985).

Root Biomass (g)

Both the parents as well as F1 crosses exhibited considerable reduction in root biomass under severe stress conditions, Reduction was more in the parents (Lines and Testers) than the F1 crosses (Fig. 1). Drought resistant cultivars have deeper-rooting than the sensitive cultivars when stressed but under WW resistant cultivars had lower growth rate. (O'Regan et al.) Lines (L2, L8), Tester (T1, T4) and crosses (L1 × T4, L3 × T3, L2 × T3, L5 × T4, L7 × T1 and L7 × T3) however, showed less reduction in root biomass even under severe stress environments and were considered to be desirable for this trait.

The present investigation revealed that mean squares due to genotypes were significant for all the traits in different environment. This suggested that sufficient variability exists in lines, testers and hybrids, which further is perquisite for combining ability (line × testers analysis) to study the nature & magnitude of gene effects. Combining ability analyses for

Table 1. List of the lines and testers selected for the inheritance studies along with their drought reaction

Lines			
HKH-164	Tolerant	HKH-279	Moderately tolerant
HKH-316	Moderately susceptible	HKH	Tolerant
HKH-645	Moderately tolerant	HKH-1025	Tolerant
HKH-1324	Tolerant	HKH-326	Susceptible
Testers			
HKH-3-4	Tolerant	HKH-295	Tolerant
HKH-803	Susceptible	HKH-1094	Moderately susceptible

Table 2. Mean and range of various root traits of lines, testers and F1 crosses in artificially created drought environments

	Vertical expansion of roots (cm)											
	Mean						Range					
	IR1	IR2	IR3	IR4	IR5	IR6	IR1	IR2	IR3	IR4	IR5	IR6
Lines	19.08	17.03	16.10	19.75	14.20	13.3	16-24	12-23	10-24	16-33	10-22	10-21
Testers	18.75	14.92	15.75	18.50	15.60	14.8	16-21	12-17	7-21	16-21	12-17	10-20
Hybrids	24.19	20.02	20.64	24.48	15.69	15.4	15-31	10-31	7-34	18-35	6-24	7-22
Checks	22.6	18.2	20.3	22.30	18.60	21.8	16-31	17-20	14-24	20-23	14-23	18-24
Horizontal expansion of roots (inches)												
Lines	13.46	13.92	11.67	11.96	6.62	6.80	12-19	8-21	5-16	9-15	4-9	3-9
Testers	12.92	10.08	10.67	12.58	9.08	7.70	12-14	9-12	4-16	12-13	4-13	4-11
Hybrids	16.38	16.65	17.31	16.08	12.30	12.50	10-21	10-22	5-22	13-23	9-18	7-24
Checks	16.50	9.50	11.30	15.2	8.90	11.30	11-26	5-18	7-22	7-32	6-16	8-14
Root Biomass (g)												
	Mean						Range					
	WW	IR1	IR2	IR3	IR4	IR5	WW	IR1	IR2	IR3	IR4	IR5
Lines	17.88	23.6	15.8	22.38	10.10	9.3	16-30.3	9.0-57.7	9.0-17.3	9.3-37.7	8-12.0	7-120
Testers	16.92	11.6	15.5	18.92	13.30	11.2	12-20	9.3-13.0	9.3-30.0	4.0-34	9-22	8-15
Hybrids	30.12	24.3	21.7	26.52	15.80	13.9	10-70	8-50	12-50	12-45	9-38	9-28
Checks	28.5	22.7	26.2	80.0	26.30	16.8	8-60	11-50	11-50	21-120	8-51	12-21
Grain yield per plant (g)												
Lines	55.71	41.12	44.46	70.96	27.50	10.20	48.0-70	20-46	30-60	50-120	2.7-39	0-23.0
Testers	53.75	32.50	42.50	59.17	26.08	11.50	40.0-70	25-50	30-50	40-180	1.0-33	0-20.0
Hybrids	67.76	53.55	46.60	77.99	30.65	19.60	18.7-100	12.3-70	11.7-100	51.7-108	0.0-65.3	0-34.7
Checks	82.70	31.20	49.10	89.30	24.70	15.30	80-106	25-43.6	33.75	0.6-116	18-33	0-25

Table 3. Five top crosses on the basis of high per se in different environment

Vertical expansion of roots											
WW		IR1		IR2		IR3		IR4		IR5	
Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean
L3 X T2	31.3**	L3 X T2	33.0***	L1 X L3	31.0***	L3 X T4	29.0***	L7 X T4	24.0***	L7 X T4	21.7*
L1 X T3	30.7**	L5 X T4	32.7***	L1 X T4	28.0***	L6 X T3	28.7***	L2 X T1	23.0***	L5 X T4	20.0
L3 X T1	30.3**	L7 X T4	31.0***	L5 X T4	24.3***	L1 X T4	28.0***	L5 X T4	21.0***	L5 X T1	19.0
L6 X T3	28.0**	L2 X T1	30.3***	L3 X T1	25.3***	L5 X T4	28.0***	L1 X T4	21.0***	L7 X T1	19.7
L8 X T1	28.0**	L3 X T1	30.3***	L5 X T4	24.3***	L5 X T3	27.3***	L4 X T2	20.0***	L6 X T1	16.7
Best Parent	33(L3)	23.3 (L3)		22.3 (L7)		22.0 (L5)		22.0 (L5)		21.0 (L7)	
Best Check	25(VIJAY)	30.5 (G-11)		20 (VIJAY)		24 (VIJAY)		22.5 (A-76)		24 (A-76)	
Horizontal expansion of roots											
L8 X T1	23.3***	L3 X T4	20.3*	L8 X T2	22.7***	L4 X T3	20.0*	L5 X T4	20.0***	L2 X T3	21.0***
L1 X T3	20.3***	L7 X T4	22.0*	L5 X T3	22.0***	L8 X T3	21.3*	L7 X T1	18.0***	L5 X T4	24.0***
L4 X T4	20.3***	L8 X T1	20.0*	L6 X T3	21.3***	L8 X T2	22.7***	L7 X T4	18.0***	L7 X T1	17.0***
L5 X T4	20.3***	L2 X T4	20.7*	L8 X T1	21.0***	L2 X T2	20.0*	L3 X T4	17.0***	L2 X T2	15.7***
L6 X T3	20.0***	L4 X T1	20.3*	L4 X T3	20.3***	L7 X T2	20.0*	L5 X T2	20.0***	L6 X T4	15.7***
Best Parent	15(L4)	19.3 (L1)		21 (L7)		16 (L2)		9 (L5)		8.7 (L1)	
Best Check	13.5(VIJAY)	26 (G-11)		18 (G-11)		2 (G-11)		15.5 (G-11)		14 (G-11)	

* Superior over best parent.

** Superior over best check.

*** Superior over best check and best parent.

Contd...

Table 3 contd...

Vertical expansion of roots											
WW			IR1			IR2			IR3		
Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean	Crosses	Mean
L5 X T4	40*	L4 X T3	41*	L5 X L2	50**	L7 X T2	50***	L5 X T4	38*	L5 X T4	28***
L4 X T3	39*	L4 X T4	40*	L5 X T3	50**	L5 X T2	40*	L5 X T2	30*	L7 X T1	28***
L4 X T1	36*	L7 X T2	40*	L4 X T3	32	L5 X T4	40*	L3 X T4	28*	L3 X T3	27***
L7 X T2	27	L8 X T2	40*	L1 X T1	31	L5 X T3	38	L4 X T1	25*	L2 X T3	22***
L3 X T2	37*	L4 X T1	30	L1 X T3	30	L5 X T3	38	L1 X T4	22*	L3 X T4	22***
Best Parent	37.7(L1)	30.3 (L4)		57.7 (L7)		40 (L5)		12 (L8)		12 (L2)	
Best Check	120(G-11)	60 (G-11)		50 (G-11)		50 (G-11)		51 (G-11)		21 (NAVJOT)	
Horizontal expansion of roots											
L1 X T2	105*	L3 X T1	91.7*	L1 X T2	82***	L6 X T1	100***	L1 X T4	40***	L3 X T1	34.7
L6 X T1	103*	L3 X T3	90*	L1 X T1	67***	L1 X T3	93.3***	L3 X T1	35.3	L3 X T3	29.3
L3 X T1	98.3*	L4 X T2	80*	L5 X T3	62.3***	L4 X T3	80***	L4 X T1	35	L4 X T1	25
L3 X T3	96.7*	L6 X T1	85*	L5 X T1	55.7***	L1 X T1	80***	L5 X T2	30	L5 X T2	25
L4 X T2	95*	L7 X T3	80*	L1 X T3	55***	L5 X T3	70***	L3 X T3	30	L1 X T4	25
Best Parent	90 (L5)	70 (L5)		46 (L7)		70 (L5)		33.3 (L8)		20.3 (L7)	
Best Check	116.6(VIJAY)	106 (VIJAY)		43.6 (VIJAY)		75 (VIJAY)		33.3 (G-11)		25 (G-11)	

various morpho-physiological traits including yield traits revealed that both additive and non-additive gene action played an important role over the environments. Similar views have in this crop by Sharma and Bhalla (1990) and Dass *et al.* (2000). The magnitude of non-additive components was almost consistently higher for all the characteristic. This was further supported by degree of over dominance, which was greater than unity.

GCA effects

There were differences with respect to root behavior among different lines. Line L1 followed by L5 was having significant positive gca effects in most of the environments whereas, lines L4 and L6 were having positive gca effects in one and two drought environments respectively. Among testers, T4 was having positive gca effects in most of the environments and thus was most desirable tester parent. T2 and T3 were also found superior in most of the environments. But none of the tester was found superior across the environments. For horizontal expansion lines L5, L7 and L8 were having significant positive values of gca for horizontal expansion of roots in four,

three and two drought environments respectively. Among testers, T1, T2 and T3 were significant only in one drought environment whereas T4 was having significant positive values of gca effects in IR3, IR4 and IR5 and well watered (WW) conditions. For root biomass lines L3, L4 and L8 were having significant positive gca values in three of the six environments tested. Among testers, T1 was having positive significant values in IR3, T2 in IR1 and IR2, T3 in WW and IR1 and T4 in IR3, IR4 and IR5. For root biomass neither tester nor lines possessed favorable genes across the environment.

Sca effects

Magnitude of sca effects for vertical expansion of roots revealed that 12 (WW), 10 (IR1), 14 (IR2), 15 (IR3), 15 (IR4) and 14 (IR5) crosses exhibited significant positive sca effects for this trait (Table 3). Two crosses L1 $\times$ T3 and L5 $\times$ T4 were found superior across the environment and were the resultant of parents having at least one good general combiner. On the contrary, L6 $\times$ T3 and L8 $\times$ T2 were derived from the parents having poor general combining ability showed significant positive sca effects in

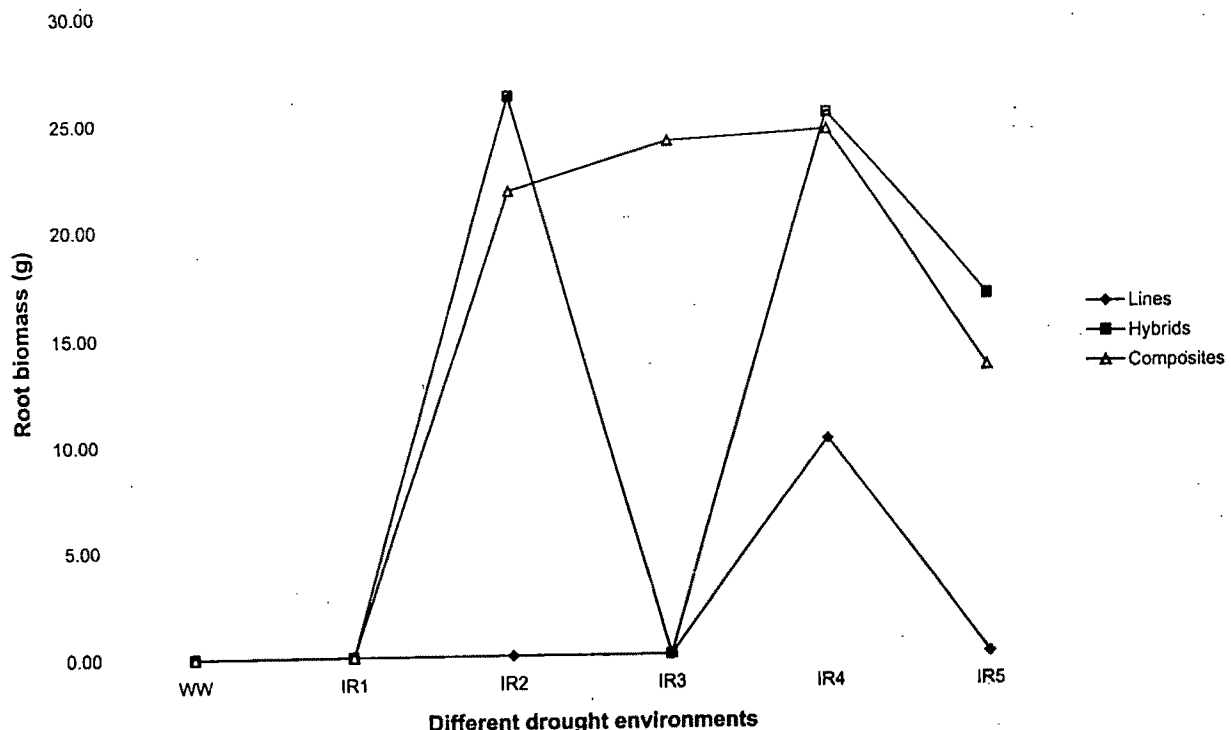


Fig. 1. Differential behaviour of different genotypes w.r.t. root biomass

the four critical stress environments. Good combinations from L × L and poor combinations from H × H were also observed. Such observations probably are due to epistasis or complementary type of gene action. L1 × T3 and L5 × T4 were the most desirable combinations for vertical expansion of roots. Out of 32 cross combinations 10 (WW), 6 (IR1), 13 (IR2), 8 (IR3), 13 (IR4) and 2 (IR5) crosses had significant positive sca effects and were desirable combinations for horizontal expansion of roots in respective environments. None of the cross combination was found desirable over the environment. Crosses L4 × T3 (WW, IR1, IR2), L3 × T1 (IR1, IR2, IR3), L3 × T4 (IR1, IR2, IR4), L6 × T2 (IR1, IR4), L7 × T2 (WW, IR2, IR3) and L8 × T2 (WW, IR2, IR4) were having positive sca effects in their respective environments and were

the resultant of high × high, low × high and high × low combinations. On the contrary, L6 × T4 (IR1 and IR4), L8 × T3 (IR1, IR3, IR4) crosses were the resultant of L × L combining parent having significant positive sca effects.

Root biomass

Crosses L2 × T3, L4 × T2, L5 × T4, L7 × T1, L7 × T4, L3 × T3 and L8 × T2 possessed high sca values in the severe stress environments were the resultant of high/average × low/high. However, the crosses viz. L4 × T3 (IR1, IR2 and IR3) and L8 × T3 (IR1, IR2 and IR3) having significant positive sca values in varied drought environments were the resultant of low × low general combining parents. None of the cross was superior across the environments for roots biomass.

REFERENCES

- Dass, Sain; Arora, P; Dhanju, K.S.; Kumar, S. and Singh, P. 2000. Gene effects for maydis leaf blight and grain yield in white maize. *Indian J. Agric. Sci.*, 70(5): 317-319.
- Fischer, K.S.; Johnson, E.C. and Edmeades, G.O. 1985. Breeding and Selection for drought resistant in tropical maize. In: International maize and wheat improvement center. Londres, 40.
- Sharp, R.E. and Davies, W.J. 1985. Root growth and water intake of maize plants in drying soils. *J. Exptl. Bot.*, 36: 170, 1441-1456.
- O'Regan, B.P.; Cress, W.A.; Staden, J. Van and Van-Straden, J. 1993. Root growth, water relations, abscisic acid and proline; levels of drought resistant and sensitive maize cultivars in response to water stress. *South-African, J. Bot.*, 59(1) 98-104.
- Sharma, J.K. and Bhalla, S.K. 1990. Genetics of some drought tolerant traits in maize. *Crop Improvement*, 17: 2, 144-149.

RESPONSE OF BERSEEM (*TRIFOLIUM ALEXANDRIUM*) TO INTEGRATED NUTRIENT MANAGEMENT

S.K. SHARMA¹ AND S.N. SHARMA²

Division of Agronomy
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Response of berseem to different combinations of N, P, K, Zn and FYM revealed that the application of NP significantly increased green fodder yield of berseem over N alone by 60-98 q/ha, dry matter yield by 7-12 q/ha, N uptake by 15-45 kg/ha, P uptake by 7-9 kg/ha, K uptake by 13-20 kg/ha, gross return by Rs. 2400-3900/ha and net return by Rs. 1500-3000/ha, whereas application of NK registered an increase of 66-70 q/ha in green fodder yield, 8.0-8.4 q/ha in dry matter yield, 14-35 kg/ha in N uptake, 5.3-5.6 kg/ha in P uptake, 10-11 kg/ha in K uptake, Rs. 2600-2800/ha in gross income and Rs. 2200-2400/ha in net return over N alone. Application of NPK + Zn resulted in a significant increase in green fodder and dry matter yield only in 1995-96, whereas NPK + FYM combination resulted an increase of 21-32 q/ha in green fodder yield, 3-4 q/ha in dry matter yield, 8-14 kg/ha in N uptake, 7-9 kg/ha in P uptake, 27-31 kg/ha in K uptake, Rs. 800-1300/ha in gross return and Rs. 400-900/ha in net return over NPK combination.

Key words : Green fodder yield, dry matter yield, NPK concentration, NPK uptake, gross return, net return.

Among fodder crops, berseem [*Trifolium alexandrium* (L.)] is an important winter crop of India. There is a higher demand of berseem fodder for dairy animals during winter and early summer. Generally farmers take multi-cuttings of berseem without supplying recommended dose of nutrients. They generally apply 20-40 kg N/ha initially and sometimes after subsequent cuttings. This type of imbalanced nutrient supply system adversely affects the fodder yield of berseem vis-a-vis soil health and even the profit to the farmers (Prasad and Kerketta, 1991 & 1992). Recommendations on integrated nutrient management in this crop is meager. A study was, therefore, conducted to study the effect of different nutrient combinations of inorganic nutrients and FYM on green fodder yield, nutrient concentration, nutrient uptake and economic return of berseem.

MATERIALS AND METHODS

A field experiment was conducted during

two crop years (1995-96 and 1996-97) at the Indian Agricultural Research Institute, New Delhi. The experiment was conducted in randomized block design having three replications. The treatment consisted of N, NP, NK, NPK, NPK+Zn and NPK+FYM. Nitrogen was applied at 40 kg/ha, P at 26 kg/ha, K at 33 kg/ha, Zn at 5kg/ha and FYM at 10 t/ha. Full dose of P, K, Zn, FYM and half dose of nitrogen was applied at the time of final ploughing of field and remaining half dose of nitrogen was applied after first cutting. Berseem variety 'Mescati' was sown during second week of October. For sowing the crop, pots were flooded with water and 15 kg/ha seed was broadcast and mixed with upper 1-2 cm soil layer by running twigs of tree in standing water. The first cutting of berseem was taken at 45 days after sowing and subsequent cutting were taken at 30-35 days interval. Fresh weight of green fodder was recorded immediately after harvest of each cutting. Plant samples at each cutting were collected, dried, ground and analysed for N, P and K concentration. The uptake of nutrients was calculated by multiplying dry matter yield with the nutrient concentration.

¹ Present Address : Department of Agronomy, College of Agriculture, Bikaner (Rajasthan).

² Corresponding author.

RESULTS AND DISCUSSION

Green fodder and dry matter yield

Application of NP increased green fodder and dry matter yield over N alone by 60-98 and 7-12 q/ha, respectively, whereas application of NK increased green fodder and dry matter yield of berseem over N alone by 67-70 and 8.0-8.4 q/ha, respectively (Table 1). Application of NPK had no significant advantage over the NP and NK combination in first year, whereas in second year, this combination increased green fodder and dry matter yield over NP and NK combination by 30-40 and 4-5 q/ha, respectively. Application of zinc with NPK fertilizers significantly increased the green fodder and dry matter yield over NPK by 33 and 4 q/ha, respectively in first year, whereas in second year, there was no significant difference between NPK and NPK+Zn. Application of NPK+FYM on the other hand increased the green fodder and dry matter yield over NPK in both the years by 21-32 and 3-4 q/ha, respectively. Husain (1971) and Samui & Bhattacharya (1982) have also reported similar effects of fertilizer and farm yard manure on berseem yield.

Nutrient concentration

Nitrogen concentration in berseem increased significantly by NP application over N alone in both the years and by NK application over N alone in 1995-96 (Table 2). Application of NPK also significantly increased N concentration in berseem over N alone but not over NP and NK. Similarly, NPK + Zn had no significant advantage over NPK alone in both the years, whereas, NPK + FYM resulted in significantly higher nitrogen content in berseem over NPK only in 1996-97.

Phosphorus concentration in berseem increased by NP application over N alone in 1995-96, whereas in 1996-97, NP application had no significant effect on P content of berseem over N alone. Similarly, application of NK had no significant effect on P concentration of berseem over N alone in both the years. Application of NPK, on the other hand, significantly increased P concentration of berseem over N alone in both the years. P concentration was further increased significantly with the application of NPK + FYM

over NPK alone. Application of NPK + Zn had no significant effect of P content of berseem over NPK alone in both the years.

Application of NP and NK had no significant effect of K concentration in berseem over N alone in both the years, whereas NPK significantly increased K concentration of berseem in 1995-96. In 1996-97 K concentration of berseem increased significantly only when a combination of NPK + Zn or NPK + FYM was applied. Higher concentrations of N, P and K due to application of NPK + FYM were earlier reported by Khurana *et al.* (1993) and Panciera and Sparrow (1995).

Nutrient uptake

Application of NP and NK significantly increased N uptake of berseem over N alone in 1995-96, whereas in 1996-97 N uptake of berseem increased significantly when NPK were applied together (Table 3). Application of Zn and FYM along with NPK had no additional significant advantage over NPK alone in both the years.

Application of NP significantly increased P uptake of berseem over N alone, whereas application of NK had no significant effect on phosphorus uptake of berseem over N alone in both the years. However, the differences between NP, NK and NPK were not significant. Further, application of NPK + Zn being at par with NPK, resulted in a significant increase of 8.9 kg P/ha over NK combination in 1995-96 only. Application of FYM along with NPK increased the phosphorus uptake by 9-9.7 kg P/ha over NPK combination. This might be due to additional application of P through FYM and its solubilizing effect on soil P.

The data on potassium uptake indicated that application of NP significantly increased K uptake by berseem over N alone only in 1995-96, whereas application of NK could not record a significant increase in K uptake by berseem over N alone in both the years. However, combined application of NPK recorded a significant increase in K uptake by berseem over N alone in both the years. These results indicate the importance of balanced use of primary nutrients for better uptake and utilization of K. Further, application of Zn or FYM along with NPK had no significant

Table 1. Effect of nutrients on green fodder and dry matter yield of berseem (q/ha)

Treatments	Green fodder yield		Dry matter yield	
	1995-96	1996-97	1995-96	1996-97
N	1217.2	1179.1	146.1	141.5
NP	1315.6	1239.4	157.9	148.7
NK	1283.9	1249.0	154.1	149.9
NPK	1293.4	1279.1	155.2	153.5
NPK + Zn	1326.6	1272.8	158.8	152.7
NPK + FYM	1325.1	1299.8	159.0	156.0
C.D. (P=0.05)	32.9	33.8	3.9	4.5

Table 2. Effect of nutrients on NPK content (%) of berseem fodder

Treatments	Nitrogen		Phosphorus		Potassium	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
N	0.66	0.80	0.28	0.27	1.05	1.01
NP	0.91	0.86	0.32	0.29	1.10	1.05
NK	0.85	0.85	0.30	0.28	1.06	1.03
NPK	0.92	0.90	0.33	0.30	1.14	1.07
NPK + Zn	0.95	0.93	0.35	0.32	1.13	1.14
NPK + FYM	0.96	0.97	0.38	0.35	1.15	1.22
C.D. (P=0.05)	0.14	0.05	0.03	0.03	0.07	0.09

Table 3. Effect of nutrients on NPK uptake (kg/ha) by berseem

Treatments	Nitrogen		Phosphorus		Potassium		Total	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
N	96.3	113.3	41.9	36.4	154.1	143.0	292.3	294.6
NP	143.7	127.9	50.5	43.6	174.4	156.2	368.6	327.7
NK	131.6	127.4	47.2	42.0	164.0	154.4	342.9	323.8
NPK	143.3	138.1	51.8	46.1	177.7	164.9	372.8	349.1
NPK + Zn	150.9	143.0	56.1	48.8	180.5	174.8	387.5	366.7
NPK + FYM	150.9	152.4	61.5	55.1	184.2	190.0	399.3	397.4
C.D. (P=0.05)	21.2	15.0	5.9	6.9	10.5	18.9	20.3	32.6

effect on K uptake by berseem over NPK in both the years.

Total NPK uptake of berseem increased significantly by the application of NP over N alone in both the years and by NK application

only in 1995-96. Effect of NPK, NP & NK on total NPK was found to be at par except that NPK application recorded a significant increase in total NPK uptake over NK combination in 1995-96 only. Application of Zn along with NPK had no

Table 4. Effect of nutrients on NPK content (%) of berseem fodder

Treatments	Nitrogen		Cost of cultivation	Potassium	
	1995-96	1996-97		1995-96	1996-97
N	48.7	47.2	9.8	38.9	37.3
NP	52.6	49.6	10.7	41.9	38.9
NK	51.3	50.0	0.2	41.2	39.8
NPK	51.7	51.2	10.1	40.6	40.1
NPK + Zn	52.9	50.9	11.5	41.5	39.4
NPK + FYM	53.0	52.0	11.5	41.2	40.5
C.D. (P=0.05)	1.3	2.5	-	1.3	1.8

extra advantage over NPK with regard to total NPK uptake. However, application of FYM along with NPK significantly increased total NPK uptake over NPK alone. Higher availability of N, P and K in soil due to higher amount of added nutrients by fertilizer as well as FYM might have increased the nutrient status in soil is reported by Deka and Singh (1984) and Prasad *et al.* (1998).

Economics

Application of NP increased the gross and net return over N alone by Rs. 3900 and Rs. 3000 per hectare, respectively in 1995-96 and by Rs. 2400 and Rs. 1500/ha in 1996-97, whereas

application of NK increased the gross and net return over N alone by Rs. 2600 and Rs. 2200 per hectare, respectively in 1995-96 and Rs. 2800 and Rs. 2400 per hectare, respectively in 1996-97. The combination of NPK increased the gross and net return over N alone by Rs. 3000-4000 and Rs. 1700-2700 per hectare, respectively. There was no additional advantage of application of NPK + Zn on gross and net return of berseem over NPK, whereas, application of NPK + FYM increased the gross and net return by Rs. 800-1300 and Rs. 400-900 per hectare, respectively over NPK alone. This shows the importance of FYM application with NPK nutrient in berseem.

REFERENCES

- Deka, J.C. and Singh, Y. 1984. Studies on rice-based multiple crop sequences. III. Nutrient uptake studies. *Indian J. Agron.*, 29 (4) : 490-94.
- Husain, M.M. 1971. Studies on the effects of P-fertilization and cutting interval on yield and quality of tetraploid berseem. Ph. D. Thesis, Division of Agronomy, IARI, New Delhi.
- Khurana, M.P.S., Singh, B., Bishnoi, S.R. and Singh, B. 1993. Effect of FYM application on the chemical composition and quality of berseem. *Journal of Research*, 39 (3-4) : 142-52.
- Panciera, M.T. and Sparrow, S.D. 1995. Effect of nitrogen fertilizer on dry matter and yields of herbaceous legumes in interior Alaska. *Canadian Journal of Plant Sciences*, 75 (1) : 129-34.
- Prasad, N.K. and Kerketta, R. 1991. Soil fertility as influenced by different cropping sequences. *Indian J. agric. Sci.*, 61 (1) : 16-19.
- Prasad, N.K. and Kerketta, R. 1992. Production, profitability and economic viability of different cropping sequences. *Indian J. Agron.*, 37(1) : 140-41.
- Prasad, R., Sharma, S.N., Singh, S., Shivay, Y.S. and Idnani, L.K. 1998. Nutrient management. In: Fifty years of Agronomic Research in India, ISA, New Delhi, 51-86.
- Samui, R.C. and Bhattacharya, A.K. 1982. Effect of Zn, B and Mo on rice and their residual effect on berseem and rice. *Indian Agriculturist*, 26 (2) : 101-106.

EFFECT OF IRRIGATION AND ANTITRANSPIRANTS ON GROWTH AND YIELD OF SPRING SUNFLOWER (*HELIANTHUS ANNUUS* L.)

RAMANI KANTA THAKURIA, HARBIR SINGH* AND TEJ SINGH

Department of Agronomy
CCS Haryana Agricultural University, Hisar, Haryana-125004

ABSTRACT

Field experiments were conducted to find out proper irrigation scheduling and antitranspirant for sunflower crop. The treatments consisted of 5 irrigation levels and 4 antitranspirants. Results revealed that sunflower crop irrigated one each at seedling, buttoning, flowering and seed developing stages recorded better results in respect of plant height, stem girth, leaf number, dry matter accumulation, leaf area index, crop growth rate at various periodical interval upto harvest; various antitranspirant treatments did not influence significantly any of the parameters. Recording significantly higher dry matter accumulation at maturity with Kaolin spray, also showed a superior tendency for all the parameters studied including the seed yield. However, no-antitranspirant-control recorded maximum benefit : cost. Interaction between irrigation levels and antitranspirants was observed to be non-significant.

Key words : Antitranspirants, irrigation levels, sunflower.

Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops. Maximum scope in harnessing the potentiality both in terms of cropped area and productivity exist in sunflower, as it is short duration, photo-thermo-insensitive, drought and salinity tolerant. Sunflower seeds contain good quality oil (34-52%) as well as high amount of protein (14%, Singh *et al.*, 1997). The oil is high in linoleic content with low cholesterol values and considered to be good for human consumption and heart patients. Due to such important quality parameters, the crop fetches higher market price leading to more acceptance by farmers.

It has been found that yield of sunflower is greatly influenced by irrigation and better results both in terms of seed and oil yield can be achieved by the application of optimum irrigation. When the crop is grown in arid and semiarid regions during spring, may require more irrigation due to higher evaporative demand of atmosphere and low rainfall. Use of antitranspirant (materials applied to plants for

the purpose of retarding transpiration) may reduce the irrigation requirement for sunflower crop due to its effect in reduction of water losses through transpiration. However, combine study on irrigation and antitranspirant on sunflower had not yet been conducted. Considering these things, the present investigation was carried out.

MATERIALS AND METHODS

The experiments were conducted during spring seasons of 1999 and 2000 at the Chaudhary Charan Singh Haryana Agricultural University Farm, Hisar. The weather during 2000 was dry in comparison to 1999 recording total precipitation of 4 mm and 39mm during the crop season, respectively. The experiment was laid out in strip plot design having 3 replications with 5 irrigation levels (I_0 : No-Post sowing irrigation, I_1 : One irrigation at seedling stage (30 DAS), I_2 : Two irrigations one each at seedling (30 DAS) and button (50 DAS), I_3 : Three irrigations one each at seedling (30 DAS), button (50 DAS) and flowering (70 DAS) and seed developing (90 DAS) stage] in main plot and 4 antitranspirants, A_0 : No-antitranspirant-control, A_1 : Kaolin (Aluminum silicate/

*Present address : Regional Agricultural Research Station, Boisa-Garumuria, North Lakhimpur, Assam-787001.

$\text{H}_2\text{Al}_2\text{Si}_2\text{O}_8\text{H}_2\text{O}$) @ 7%, A_2 : Alar ($\text{B}_9/\text{C}_5\text{H}_{12}\text{N}_2\text{O}_3$) @ 0.001% and A_3 : Potassium sulphate (K_2SO_4) @ 4% in sub-plots. The sunflower (hybrid MSFH-8) crop (seed presoaked in water for 8 hours) was sown on 18th February, 1999 and 24th February, 2000 by dibbling at 30 cm interval in rows 60 cm apart. The crop was fertilized with uniform dose of 50 kg P_2O_5 /ha through single super phosphate. A buffer channel of 0.5 m width was provided on all sides of the main plot. Measured volume of water was applied using Parshall Flume (Parshall, 1926) of 8.0 cm throat. Post sowing irrigations (each of 6.0 cm depth) to sunflower were scheduled on critical stages as per treatment.

Different growth parameters viz., plant height, stem girth, leaf number and dry matter accumulation; morpho-physiological parameters viz. leaf area index (LAI), crop growth rate (CGR) and leaf area duration (LAD) were studied 20 days periodical interval from 35 to 95 days after sowing (DAS) and at harvest maturity. Plant height in "cm" was recorded from the base of the plant upto the leave whorl during vegetative and upto the base of button/capitulum during reproductive phase. The stem girth (diameter-mm) was measured at about 5cm above the ground level with the help of vernier caliper.

Fully expanded and photosynthetically active green leaves were counted from 3 plants taken for dry matter estimation and was averaged to get the number of leaves/plant. Leaves/button/capitulum were separated from stem and stems were chopped into a desired length. all the individual plant parts were dried first in shade and then in oven at 60°C to the constant weight. Dry weight(s) of leaves and other plant parts were added up and averaged to record dry weight per plant. Different morpho-physiological analyses of growth were calculated using standard formulae.

Seed yield of sunflower was calculated from sun dried capitulum of net area (4.8 m × 2.4 m) of each of the plots and finally, the benefit : cost, dividing the gross return by total cost.

RESULTS AND DISCUSSION

Growth parameters

The growth of the sunflower measured in terms of plants height, stem girth, seed number and dry matter accumulation at different periodical intervals was influenced significantly by irrigation level except at 35 DAS for plant height and stem girth (Table 1). With the increase in irrigation number from 1 in I_1 to 4 in I_4 resulted increase in value(s) of various growth parameters, maximum and minimum being recorded with I_4 and I_0 , respectively. The better growth under higher irrigated condition might be attributed to adequate soil moisture supply, the sunflower crop(s) had, in comparison to crop with less frequent irrigation. The expansion of cells and cell divisions are enhanced due to adequate supply of water resulting in the stem elongation, leaf number and weight of stems, leaves and reproductive parts. Tomer *et al.* (1997) and Prabhudeva *et al.* (1998) also observed improvement in overall growth of sunflower with adequate moisture supply.

Except dry matter accumulation at harvest maturity, influence of antitranspirants on all the growth parameters studied in different periodical interval was non significant. However, in comparison to control, application of antitranspirants, Kaolin spray (A_1) resulted in better result for all the growth parameters followed by potassium sulphate (A_3). Favourable effects of kaolin spray (A_1) on plant growth might be attributed to reduction in transpirational loses of water due to reflection of part of solar radiation incident on leaf surface, thus, making the soil moisture available for better growth over longer period. The beneficial effect of kaolin spray are in conformity with the findings of Lal *et al.* (1994) and Malik (1994).

Morpho-physiological parameters

LAI, CGR and LAD were significantly improved at all the growth stages with increasing level of irrigation except LAI at 35 DAS and LAD during 95 DAS to harvest maturity (Table 2). The variations in the trend of results for LAD during 95 DAS to harvest maturity from the other growth period might be due to rainfall at the

Table 1. Plant height, stem girth, leaf number, dry matter accumulation as influenced by irrigation and antitranspirants (mean of two years)

Treatments	Plant height (cm)	Stem girth (mm-diameter)	Leaf number/plant	Dry matter accumulation (g/plant)
35 DAS55 DAS75 DAS95 DAS Har.	35 DAS55 DAS75 DAS95 DAS Har.	35 DAS55 DAS75 DAS95 DAS Har.	35 DAS55 DAS75 DAS95 DAS Har.	35 DAS55 DAS75 DAS95 DAS Har.
Irrigation level				
I ₀	11.21 37.36 96.02 105.33 105.74 2.50 5.93 7.79 10.06 9.70 7.61 14.84 19.51 26.53 23.72 2.42 7.67 25.77 67.54 69.47			
I ₁	12.25 59.92 133.92 146.12 146.86 2.88 10.19 12.68 16.36 15.90 11.14 20.61 26.54 32.83 29.71 3.25 17.41 57.98 122.20 122.77			
I ₂	12.23 60.51 136.83 142.46 149.34 2.88 10.72 13.66 16.68 16.27 11.32 21.01 27.26 33.98 30.77 3.26 17.89 63.42 127.39 131.61			
I ₃	12.20 60.30 139.66 139.66 151.55 2.89 10.72 13.85 16.89 16.46 11.31 20.96 27.92 35.63 32.09 3.26 17.87 65.84 132.63 140.91			
I ₄	12.23 59.98 139.67 139.67 153.10 2.90 10.74 13.88 17.07 16.61 11.60 21.01 27.99 36.63 33.26 3.27 17.89 66.86 135.98 148.45			
S.E.m.±	0.47 0.56 0.66 0.54 0.49 0.18 0.09 0.05 0.10 0.18 0.19 0.21 0.24 0.20 0.49 0.03 0.10 0.47 0.57 0.64			
C.D.at5%	NS 1.81 2.16 1.76 1.59 NS 0.30 0.17 0.32 0.57 0.61 0.66 0.61 0.63 1.61 0.10 0.30 1.52 1.86 2.09			
Antitranspirants				
A ₀	12.01 55.38 128.69 139.96 140.79 2.78 9.61 12.24 15.22 14.83 10.48 19.51 25.57 32.68 29.50 3.09 15.48 55.16 116.01 121.40			
A ₁	12.01 55.78 129.62 141.14 141.61 2.81 9.72 12.50 15.63 15.19 10.58 19.91 26.11 33.51 30.14 3.10 15.98 56.70 117.92 123.84			
A ₂	12.06 55.61 129.21 140.70 141.32 2.81 9.64 12.32 15.29 14.89 10.56 19.58 25.75 32.99 29.89 3.09 15.69 55.73 116.74 122.31			
A ₃	12.01 55.68 129.35 140.97 141.55 2.83 9.68 12.43 15.50 15.04 10.57 19.73 25.94 33.28 30.09 3.09 15.84 56.32 117.17 123.01			
S.E.m.±	0.22 0.51 0.55 0.80 0.55 0.04 0.19 0.15 0.12 0.24 0.13 0.28 0.23 0.31 0.34 0.02 0.18 0.36 0.43 0.55			
C.D.at5%	NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS 1.91			

latter part of the crop seasons, where regeneration was observed in no-post sown irrigation or comparatively less irrigated sunflower. Improved LAI, CGR and LAD in frequently irrigated sunflower might be ascribed to mere photosynthesis from increased leaf area and efficient utilization of CO₂ due to better internal water balance. Differential effects of irrigation level at varying growth stages on LAI and CGR have also been reported by Singh (1996) and Raj *et al.* (1998).

Application of antitranspirants did not affect the LAI, CGR and LAD significantly at any growth stages (Table 2). However, except LAD during 95 DAS to harvest maturity, no-antitranspirant - control (A₀) recorded the lowest value while kaolin (A₁) spray recorded the highest at all the growth stages. Corroborative finding were also observed by Malik (1994) for summer moong.

Seed yield

Seed yields (Table 2) in both the years and in pooled were increased significantly with the increase in number of irrigation, the maximum being recorded (21.93, 17.50 and 19.71 q/ha during 1999, 2000 and pooled, respectively) with 4 irrigations (I₄) treatment and minimum being with control (I₀). Seed yield of sunflower in 1999 was higher (33.39%) than 2000 as comparatively less rainfall (approximately 10 times lesser) was recorded during later year. The highest seed yield under frequently irrigated conditions might be due to increased reserve soil moisture content, which improved internal plant water status and growth. These results confirm the findings of Raj *et al.* (1999) and Singh *et al.* (2000).

Effect of antitranspirants on seed yield was non-significant. This might be due to insufficient improvement of internal plant water balance after antitranspirants spray. Similar findings were also reported by Khanvilkar *et al.* (1987) for sunflower.

Benefit : Cost ratio

Marked increase in the benefit : cost ratio due to increase in number of irrigation was observed (Table 2). Four irrigation treatment (I₄) scheduled at seedling, buttoning, flowering and seed developing stages recorded highest (1.87) benefit : cost ratio, while the minimum was recorded with no - irrigation - control (I₀). The highest benefit : cost ratio from higher irrigational treatment is due to production of more seed in comparison to the expenditure incurred on irrigation treatment.

In case of antitranspirant spray, no-antitranspirant - control (A₀) recorded the highest benefit : cost ratio (1.63) followed by potassium sulphate (A₃) spray (1.30). The highest benefit : cost ratio as obtained from without any antitranspirant spray is because of the less economic benefit from antitranspirant spray in comparison to its cost involved.

Thus, from the study, it may be concluded that under the agro-climatic condition of North West Haryana, four irrigations one each at seedling buttoning, flowering and seed developing should be applied to sunflower crop for its maximum production and economic return. However, reliance on spraying of antitranspirant in minimizing the irrigation requirement is not satisfactory for economically viable recommendation.

REFERENCES

- Khanvilkar, S.A.S., Singh, N.P. and Hukkeri, S.B. 1987. Response of spring sunflower to irrigation, mulch and antitranspirants. *Journal of Maharashtra Agricultural Universities*, Pune 12:322-5.
- Lal, B., Kaushik, S.K. and Gautam, R.C. 1994. Effect of soil moisture regime, Kaolin spray and phosphorus fertilizer on nodulation, P-uptake and water-use of lentil (*Lens culinaris*). *Indian J. Agron.*, 39 (2) : 241-245.
- Malik, A.C. 1994. Effect of various plant population, moisture regimes and antitranspirants on growth, yield and quality of summer mungbean (*Vigna radiata* (L) Wilczek) Ph. D. thesis, Chaudhary Charan Singh Haryana Agricultural University, Hisar.
- Parshall, R.L. 1926. The improved venturiflume *Transactions, American Society of Civil Engineers*, 89 : 841-80.

- Prabhudeva, T.V.; Chalapathi, M.V.; Thimmegowda, S.; Devakumar, N.; Gangadhereswar, G.R. and Mallikarjuna, K. 1998. Soil moisture stress and drought susceptibility index in sunflower. *Indian Agri.*, **42**(4) : 187-289.
- Raj, B., Singh, T. and Singh, Harbir. 1999. Genotypes irrigation and fertility effects on seed yield, water use and water use efficiency of spring sunflower (*H. annuus* L.) *Indian J. Agril. Sci.*, **69**(2) : 101-105.
- Raj, B., Singh, T., Singh, Harbir and Singh, B.P. 1998. Effect of genotypes, irrigation and fertility levels on growth and yield of spring sunflower (*H. annuus* L.) *Haryana J. Agron.*, **14**(2) : 206-210.
- Singh, Harbir, Agarwal, S.K. and Singh, K.P. 1997. Sunflower production technology-a-review. In : *Agro's Ann. Rev. of crop Ecology*. Vol. 1, (Ed.) A.K. Dahama, pp. 243-258, *Agro Botanica*, Bikaner, India.
- Singh, M. 1996. Response of sunflower (*Helianthus annuus* L.) genotypes of irrigation and nitrogen in sunflower-cotton cropping system. Ph. D. Thesis. Chaudhary Charan Singh Haryana Agricultural University, Hisar. (India).
- Singh, M.; Singh, Harbir; Singh, T., Jhorar, R.K. and Singh B.P. 2000. Seed yield, water use and water-use efficiency of Sunflower (*H. annuus* L.) genotypes under irrigation and nitrogen variable. *Indian J. Agron.*, **45** (1) : 188-192.
- Tomar, H.P.S., Singh, H.P. and Dadhawal, K.S. 1997. Effect of irrigation, nitrogen and phosphorus on growth and yield of spring sunflower (*H. annuus*). *Indian J. Agron.*, **42**(1) : 169-172.

GENETICS OF SEED SHAPE IN CHICKPEA (*CICER ARIETINUM* L.)

H.S. MEENA, J. KUMAR AND S.S. YADAV

Division of Genetics
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Inheritance of seed shape in chickpea were studied during years 1999-2000 and 2000-2001. Five genotypes, BG 1006 (desi), BGD 112 (desi), DG 843 (pea type), DG 1360 (desi) and ICC 8151 (kabuli) were selected and crosses were attempted among all possible combinations. Segregation in F₂ populations revealed that desi types are dominant over both kabuli and pea types while pea types are dominant over kabuli seed shape. The results on seed shape inheritance indicated the digenic control of seed shape in chickpea.

Key words : Chickpea, inheritance, seed shape.

Chickpea (*Cicer arietinum* L.) has been known in India for a long time. It is said to be one of the oldest pulse known and cultivated from ancient times in both Asia and Europe. In India chickpea occupies the premier position among pulses in terms of area as well as production. The seed characters in this crop determine to a large extent the spread of the new varieties and the manner of seed use varies with seed traits specially seed shape. There are three distinct seed shape in chickpea; the angular (desi type) being the most common, followed by owl's head shape (kabuli type) and roundish or pea seed shape (pea type). Pea type chickpeas are good for parching and are quite popular in central India. World germplasm collections of chickpea have considerable variations in seed shape. The study on inheritance of seed shape would yield information of great fundamental and practical importance.

MATERIALS AND METHODS

The present investigation was conducted during the years 1999-2000 and 2000-01 at Division of Genetics, IARI, New Delhi. The material used were five genotypes selected from a large chickpea collection maintained in chickpea breeding programme of Genetics Division. These lines were having variability for different seed shapes. The genotypes used were BG (desi), BGD 112 (desi), DG 843 (pea) DG 1360 (desi) and ICC 8151 (kabuli).

The crosses were attempted among all selected genotypes during rabi 1999-2000. The standard cultural practices were followed to raise a good crop. Emasculation and pollination were done following conventional methods. The F₁ seed along with parents were sown at off-season nursery, Dharwad, Karnataka in Kharif 2000. The seeds from all the parents and F₁ plants were collected at maturity. The seeds from each F₁ plant were critically examined for seed shape and the data were recorded on individual plant basis.

In rabi 2000-01, the F₁ and F₂ generation along with their respective parents were planted at IARI farm. Depending on seed availability in F₂ 20-30 rows of each F₂ population were grown along with a single row of each of the parents and F₁'s. The F₃ seeds from individual F₂ plants were collected and examined critically for seed shape. The data were recorded on individual plant basis and the seeds from parental lines and F₁ plants were compared with seeds from F₂ plants. The segregation for seed shape was analysed by χ^2 test to determine the goodness of fit of the observed segregation with expected ratios.

RESULTS AND DISCUSSION

The inheritance pattern of seed type in chickpea was studied in crosses involving desi, kabul and pea type parents which are presented

as follows.

Desi vs Kabuli types

The crosses were made among three desi (BG 1006, BGD 112, DG 1360) and one kabuli (ICC 8151) parents. The F_1 plants produced seeds having desi types in all the three crosses indicating the dominance of desi over kabuli types. The F_2 population of all these crosses segregated into 12 desi : 3 pea; 1 kabuli ratio (Table 1). The χ^2 analysis showed that segregation in all crosses were in agreement with the expectation of 12:3:1 ratio ($\chi^2 = 0.242-3.532$; $P = 0.171-0.886$). These results indicate the digenic inheritance of desi vs kabuli chickpea. Kumar *et al.* (1985) observed similar results in desi $\times$ kabuli crosses. Knights (1980), Hawtin and Singh (1980) also conducted similar experiments but most of them presented results in percentage of different seed shapes in F_2 and no conclusion were drawn regarding mode of inheritance.

The observation in this investigation show that the desi and kabuli types are differentiated by two genetic factors. The kabuli types may be the result of double recessive condition of those genes. The modification of normal digenic ratio (9:3:3:1) into 12:3:1 indicates the presence of dominant epistasis.

Desi vs Pea types

Three crosses viz., BG 1006 (desi) $\times$ DG 843 (pea), BGD 112 (desi) $\times$ DG 843 (pea) and DG 1360 (desi) $\times$ DG 843 (pea) were analyzed for inheritance studies of desi vs pea types. Desi types were completely dominant over pea types, as F_1 plants had always desi types seeds and F_2 population segregated into 3 desi : 1 pea type ratio in each cross (Table 2). Singh and Ekbote (1936), Ghatge and Kohle (1985) found similar results when studied the crosses between wrinkled and round seed shape.

These observations indicate the monogenic difference between desi and pea type seeds. Generally desi type seeds are more common and wide spread than kabuli or pea types therefore, desi seeds may have wild/normal alleles and show dominance over other two types as wild type traits generally show dominance.

Pea vs Kabuli types

Pea type seeds were found to be completely dominant over kabuli types as the F_1 plants had totally pea type seeds. Based on F_2 segregation of 163 plants of cross between DG 843 (pea) $\times$ ICC 8951 (kabuli), its monogenic nature was confirmed as 125 pea : 38 kabuli plants is F_2 population fit well to 3:1 ratio (Table 3). These

Table 1. F_2 segregation for seed type in *desi vs kabuli* chickpea crosses

Cross	F ₁	F ₂ segregation			d.f.	χ^2 (12:3:1)	P value
	phenotype	Desi	Pea	Kabuli			
<i>Desi × Kabuli</i>							
BG 1006 × ICC 8151	Desi	106	24	8	2	0.242	0.8860
BGD 112 × ICC 8151	Desi	183	37	9	2	3.532	0.1710
DG 1360 × ICC 8151	Desi	151	41	15	2	0.569	0.7523

Table 2. F_2 segregation for seed type in *desi vs pea* type chickpea crosses

Cross	F ₁ phenotype	F ₂ segregation		d.f.	χ ² (3:1)	P value
		Desi	Pea			
<i>Desi × Pea</i>						
BG 1006 × ICC 843	Desi	94	35	1	0.313	0.5758
BGD 112 × DG 843	Desi	141	45	1	0.065	0.7987
<i>Pea × Desi</i>						
DG 843 × ICC 8151	Desi	130	35	1	1.263	0.2610

Table 3. F₂ segregation for seed type in *pea* vs *kabuli* chickpea cross

Cross	F ₁ phenotype	F ₂ segregation		d.f.	χ^2 (3:1)	P value
		Desi	Pea			
BG 843×ICC 8151	Kabuli	125	38	1	0.247	0.639

observations indicate that there is a difference of only one gene between parental seed shapes and kabuli types resulted from the homozygous recessive condition.

In the present investigation on inheritance of seed shape, desi and kabuli types were found to be differentiated by two genes while desi vs pea and pea vs kabuli types by a single gene. Kabuli

types were found to be recessive to both desi and pea types whereas, pea type was recessive to desi seeds. Based on these observations, the genetic constitution of desi, pea and kabuli types is suggested as D-P- or D-pp, ddP- and ddpp, respectively. However, the genetic constitution of desi, pea and kabuli type strains in present study are most probably DDPP, ddPP and ddpp, respectively.

REFERENCES

- Ghatge, R.D. and Kohle, A.K. 1985. Genetic studies in Bengal gram VI. A triangular cross. *Res. J. MPKV.*, 4 : 77-22.
- Hawtin, G.C. and Singh, K.B. 1980. Kabuli-desi introgression problems and prospects. In : proc. Intern. Workshop on chickpea improv; ICRISAT, Hyderabad, India, 26 Feb.-2 March, 1979, pp. 51-80.
- Knights, E.J. 1980. Kabuli-desi introgression. The experience in Australia. In Proc. Intern. Workshop on chickpea improvement; ICRISAT, Hyderabad, India, 26 Feb. - 2 March, 1979, pp. 70-74.
- Kumar, J., Bahl, P.N. and Raju, D.B. 1985. Seed type variation in desi-kabuli crosses of chickpea. *Intern. Chickpea Newsletter*, 1:1-2.
- Singh, H. and Ekbote, R.B. 1936. The inheritance of seed characters in gram (*Cicer arietinum* L.). *Indian J. agric. Sci.*, 6 : 1087-1104.

IMPACT OF DIRECT SELECTION FOR SEED YIELD ON YIELD COMPONENTS IN CHICKPEA (*CICER ARIETINUM* L.)

SHORAJ SINGH, S.K. MISHRA AND A.K. AHLAWAT

Division of Genetics
Indian Agricultural Research Institute
New Delhi-110012

ABSTRACT

Direct selection for improvement of seed yield in segregating populations was carried out by three breeding methods in four chickpea crosses. The impact of direct selection for seed yield was assessed to study its influence on yield components. The result showed that whenever improvement in seed yield was accomplished other traits like branches per plant, pods per plant and biological yield per plant were improved concurrently. Therefore, it was suggested that selection for seed yield along with the most important trait for further population improvement in chickpea. While comparing the relative performance of different breeding methods. It was found that more and more superior high yielding segregants were obtained when population was advanced through selected bulk method of breeding.

Key words : Chickpea, population, genetic improvement, selection.

Chickpea (*Cicer arietinum* L) is an important pulse crop and is rich in protein and other micro- and macro-nutrients. It is well adapted to stress and poor-agro-adaphic environments. The yield level of chickpea are low and are different selection approaches are being applied for improvement. These include, direct selection for seed yield and selection for yield components, using pedigree method, selected bulk and random bulk methods of breeding. As selection for more than one traits simultaneously is difficult, therefore, selection for single trait, which can influence other component traits, may be more advantageous. Therefore, if a breeder can concentrate and look forward for a single traits like seed yield, he may handle large number of populations and can identify more number of high yielding segregants. Since such studies have not been carried out in segregating populations by applying prominent breeding methods. Therefore, the present investigation was conducted with a view to work out the effectiveness of breeding methods.

MATERIALS AND METHODS

The experimental materials was consisted of four chickpea crosses viz. : H86 - 143 × Pusa

256. GB 303 × HMS 6, Pusa 267 × Flip 87-9C and BG 356 × ICCV 7344; involving desi and kabuli cultivars. These crosses were advanced from F₂ to F₅ generations using pedigree selection, selected bulk and random bulk methods of breeding. The selection for seed yield only was carried out in all the segregating populations of different crosses advanced by different breeding methods. The selection intensity was maintained at 10 per cent at all the stage of selection.

All the segregating populations belonging to different crosses were evaluated upto F₅ generation by three breeding methods separately in a randomized block design. The line to line and plant to plant distance was maintained at 40 and 20 cm apart. During final year of experimentation 1997-98 all the segregating populations were planted together including parents to minimize experimental error.

Single plant observations for six agronomic traits viz., productive branches per plant, productive pods per plant, seeds per pod, total biomass and seed yield per plant were recorded in F₂ to F₅ generations of all the crosses advanced by different breeding methods during 1994-98. The 10 top yielding single plants were selected

in F_2 , F_3 , F_4 and F_5 populations. Other traits were compared within and between segregating populations. The correlation coefficient between yield and yield components in top yielding plants was calculated in all the crosses.

RESULTS AND DISCUSSION

Keeping in view the importance of genetic variation in selection for high yield potential, the present investigation was carried out for evaluation the efficiency of direct selection for single trait (seed yield) in four chickpea crosses, advanced by three breeding methods, separately. A total of 10 highest yielding plant progenies per cross in F_5 generation, emanating from each of the base F_2 generation were evaluated and compared with the rest of the population and best of the parents.

The impact of direct selection of seed yield on other yield components was measured in terms of increase in seed yield of highest yielding plant over high yielding parent and average yield of rest of the segregating population. Due to continuous segregation in F_2 , F_3 and F_4 generations. The comparison between highest yielding segregants viz. best parent and rest of the population was restricted only to F_5 generation, which is supposed to be more homogygous. The results are presented in Table 1.

The seed yield along with other traits in F_5 generation was recorded separately for all the crosses advanced by pedigree, selected bulk and random bulk method of breeding. The maximum average seed yield of top yielding segregants in cross 1 (43.0 g), cross 2 (33.9 g), cross 3 (30.9 g) and cross 4 (32.3 g) were recorded in F_5 generation advanced by selected bulk method and followed by pedigree 35.5, 30.1, 27.6 and 28.9 and random bulk method 33.9, 29.7, 25.4 and 27.1 g, respectively. The average seed yield of rest of the F_5 population was recorded in cross 1-28.2, cross 2-22.6, cross 3-25.4 and cross 4-24.6 g, respectively, advanced by selected bulk method which was followed by pedigree 23.1, 20.5, 21.5, 18.9 g and random bulk method 24.9, 21.1, 19.2 and 17.8, respectively.

It was interesting to note that irrespective

of cross-highest seed yield was recorded in F_5 generation in all the crosses when advanced by selected bulk method, followed by pedigree and random bulk methods, respectively. Similar trend was also observed in case of the population. Its indicates that selected bulk appears to be an efficient method in isolating high yielding progenies followed by pedigree and random bulk method.

It is pertinent to mention that other three traits viz. productive branches per plant, productive pods per plant and total biomass per plant were also increased concurrently in F_5 generation of all the crosses, when advanced by selected bulk method. Other two traits viz. seeds per pod and seed weight were not effected in highest yielder vs different breeding methods separately. It may be due to high heritability and stable nature of these two traits.

The present increase in seed yield of top yielding crosses in F_5 generation was compared with rest of the populations and best of the parent for all the crosses advanced by three breeding methods separately. The percent yield superiority of top yielding segregant was highly significant in all the F_5 populations irrespective of cross and breeding method over rest of the population in cross 1 (52.2%), cross 2 (50.0%), cross 3 (22.0%) and cross 4 (31.0%) when advanced by selected bulk method. These value were 53.2, 46.6, 28.2 and 53.0% by pedigree method and 36.1, 49.9, 32.2 and 51.8% by random bulk method, respectively. More and less same trend was observed for other three traits viz. productive branches per plant, pods per plant and biological yield per plant. However, in case of seeds per pod and seed weight there was no increase.

An interesting trend in F_5 generation of most of the crosses emerged that seed yield of top yielding segregants was significantly higher than rest of the population and the best parent in all the crosses advanced by three breeding methods. Khorgade *et al.* (1985) have also suggested this type of pattern in segregating population. This type of trend in the increase in seed yield of top yielding segregants established that the development of transgressive segregants

is possible via single trait selection, through directional selection for higher yielding genes. This is possible through the accumulation of more and more favourable genes. Secondly both the parents may be having specific gene combination and are supplementing each other in combination.

In the parent selection scheme the superior single plants were selected for the yield only on visual basis for higher number of branches per plant and pods per plant. It was observed in most of the cases that with the selection for higher seed yield the selection for more branches per plant, pods per plant and total biomass per plant was confirmed. These observations are in agreement with those of Kumar (1989) and Lal *et al.* (1973). Because, as seed yield was increasing the productive branches per plant, productive pods per plant and high biological yield per plant were also increasing in the same fashion and direction.

The correlation coefficient between these traits in all the crosses advanced by three breeding methods separately, were also compared to the influenced of direct selection for seed yield on other yield components. An interesting pattern of inter relationship in positive direction with high magnitude was obtained between seed yield and its major componential traits like number of productive branches per plant, number of productive pods and total biomass per plant in all the crosses. It is evident from this type of correlation and interrelationship between these traits that the selection for major trait will influence the performance of secondary traits during course of advancement. The seed yield association was obtained without any particular direction and magnitude with seeds per pod and seed weight in all the F5 populations, which showed the independent and high heritable nature of these two traits.

The results showed non-significant

correlation of seed yield with seeds per pod and seed weight in F5 generation in all the crosses. This indicated high heritable nature of these two traits and showed that the increase in seed yield and selection for higher yield may not increase the seeds per pod and seed weight simultaneously. While comparing the relative superiority of different breeding methods it was noticed that superior segregants were obtained in greater proportions when segregating populations were advanced by selected bulk method. This is possible because during the course of selection, directional selection for superior performing plants were exercised and more and more super yielding genes were being selected for different traits, thus, accumulation of desirable gene combinations may have taken place simultaneously in those particular plants.

In the present selection scheme the superior single plants were selected for the yield only on visual basis for higher number of branches and pods except random bulk method. After the harvest, actual counting was carried out for these traits. After seed yield recording, the other yield components of higher segregants were compared. It was observed in most of the cases that the selections for higher seed yield indirectly and, automatically promoting for higher branches, number of pods and high biological yield. The similar opinion were also given by Kumar (1989) and Lal *et al.* (1973). This is possible, because the seed yield is controlled by polygenes. It is important to know those traits, which help to increase, seed yield and weather traits are controlled by independent genes. It is not established fact that in chickpea, number of branches and number of pods are directly associated with seed yield because if number of branches increase that number of pods also increase which increase total number of seeds per plant i.e. yield. Mishra *et al.* (1991) also demonstrated that yield per plant may be suitable selection criteria in early generation selection in rice.

Table 1. Seed yield and five other traits of F5 top yielder segregants over rest of the populations and the best parent

Cross/method	Grain yield/ plant(g)	% increase over R.P. and B.P.	Productive branches /plant	% increase over R.P. and B.P.	Productive pods/ plant	% increase over R.P. and B.P.	Biological yield/ plant(g)	% increase over R.P. and B.P.	Seed/ pod	% increase and B.P.	100- seed weight (g)	% increase over R.P. and B.P.
Selected bulk method												
Cross 1												
Top Yielder	43.00	-	40.15	-	150.35	-	109.25	-	1.14	-	25.91	-
Rest Population	28.24	52.27	30.37	32.20	98.55	52.56	67.94	60.80	1.15	-	24.77	0.57
Best Percent	25.15	70.79	24.04	67.0	75.50	107.38	64.00	69.62	1.12	1.78	30.66	-
Cross 2												
Top yielder	33.94	-	32.45	-	119.50	-	84.00	-	1.27	-	22.91	-
Rest population	22.61	50.11	25.20	28.77	80.21	48.98	52.29	60.64	1.26	0.79	22.85	0.26
Best Percent	29.00	17.03	25.30	28.26	109.70	8.93	70.00	20.00	1.21	4.96	22.61	1.33
Cross 3												
Top yielder	30.94	-	26.40	-	86.90	-	74.65	-	1.20	-	29.96	-
Rest population	25.35	22.05	22.83	15.64	73.61	18.05	61.26	21.86	1.20	-	28.72	4.32
Best Percent	27.00	14.59	24.70	6.88	75.00	15.86	64.00	16.64	1.19	0.84	37.75	-
Cross 4												
Top yielder	32.30	-	27.97	-	98.30	-	79.75	-	1.75	-	29.36	-
Rest population	24.59	31.35	23.00	21.61	77.15	27.41	63.10	26.45	1.15	-	27.90	5.23
Best Percent	28.00	15.36	24.30	15.10	88.00	11.70	72.00	10.76	1.22	-	28.57	2.77
Pedigree Selection												
Cross 1												
Top yielder	35.45	-	32.25	-	111.70	-	82.50	-	1.07	-	29.02	-
Rest population	23.14	53.19	25.46	20.67	75.94	47.09	56.88	45.04	1.07	-	28.64	1.33
Best Percent	20.65	71.68	20.70	55.80	60.60	64.32	51.90	58.97	1.11	-	31.02	-
Cross 2												
Top yielder	30.05	-	28.50	-	96.30	-	73.60	-	1.29	-	24.30	-

Contd...

Table 1 contd...

Rest population	20.50	46.59	23.13	28.78	70.60	36.40	51.44	42.80	1.24	4.03	23.63	2.84
Best Percent	27.50	9.27	24.50	16.33	89.00	8.20	68.00	8.24	1.28	0.78	23.00	5.65
Cross 3												
Top yielder	27.62	-	24.60	-	77.80	-	67.47	-	1.19	-	30.35	-
Rest population	21.54	28.23	20.26	21.42	58.50	32.09	52.60	26.37	1.19	-	29.03	4.51
Best Percent	24.96	10.66	22.10	11.11	63.48	22.73	62.00	7.21	1.30	-	32.20	-
Cross 4												
Top yielder	28.95	-	26.60	-	89.90	-	75.00	-	1.18	-	24.18	-
Rest population	18.92	53.01	20.67	28.69	62.29	44.32	52.00	44.23	1.10	7.27	27.00	-
Best Percent	26.0	11.35	23.80	11.76	80.00	12.38	70.00	7.14	1.18	-	27.10	-
Random bulk selection												
Cross 1												
Top yielder	33.92	-	36.80	-	127.50	-	84.90	-	1.11	-	24.89	-
Rest population	24.93	36.06	26.26	40.14	79.78	59.81	64.30	32.04	1.13	-	24.21	2.81
Best Percent	23.86	42.16	22.20	65.77	73.60	72.50	53.59	58.43	1.10	0.90	30.26	-
Cross 2												
Top yielder	29.70	-	29.87	-	94.40	-	79.25	-	1.24	-	23.29	-
Rest population	21.12	49.86	23.58	26.68	69.88	35.00	53.05	49.39	1.24	-	25.10	8.73
Best Percent	28.28	11.92	25.70	16.22	90.00	4.88	70.00	13.21	1.21	2.48	22.01	5.86
Cross 3												
Top yielder	25.41	-	23.95	-	74.90	-	61.40	-	1.22	-	28.13	-
Rest population	19.22	32.21	18.73	27.87	57.96	29.23	47.95	28.05	1.22	-	29.13	-
Best Percent	23.50	8.13	22.00	8.86	65.00	15.23	59.40	3.36	1.20	1.67	34.12	-
Cross 4												
Top yielder	27.05	-	24.73	-	80.55	-	68.90	-	1.13	-	28.80	-
Rest population	17.82	51.80	18.26	35.43	57.29	40.60	44.71	44.41	1.14	-	29.46	-
Best Percent	24.00	12.71	22.20	11.39	73.00	10.34	64.20	7.66	1.15	-	29.00	-

Table 2. Correlation between seed yield and five traits in F₅ population in four crosses of chickpea advanced through different methods

Methods/cross	Character combination				
	Seed yield Vs	Seed yield Vs	Seed yield Vs	Seed yield Vs	Seed yield Vs
	Branch per plant	pod per plant	biomass	seed per pod	seed weight
Selected bulk method					
Cross 1	0.556*	0.874**	0.967**	0.448	0.435
Cross 2	0.534*	0.663*	0.960**	0.023	-0.069
Cross 3	0.747**	0.750**	0.815**	-0.172	-0.398
Cross 4	0.799**	0.749**	0.954**	0.431	-0.367
Pedigree selection					
Cross 1	0.577*	0.556*	0.932**	-0.127	0.336
Cross 2	0.529*	0.514*	0.985**	0.421	0.455
Cross 3	0.735**	0.727**	0.876**	0.383	-0.211
Cross 4	0.811**	0.865**	0.987**	0.270	0.229
Random bulk method					
Cross 1	0.537*	0.510*	0.848**	-0.047	-0.305
Cross 2	0.672*	0.847**	0.920**	0.275	-0.110
Cross 3	0.750**	0.670*	0.919**	-0.369	0.485
Cross 4	0.534*	0.584*	0.980**	0.237	0.322

Note : * and ** significant at 5% and 1% levels, respectively.

REFERENCES

- Khorgade, P.M., Narkgade, M.N. and Raut, S.K. 1985. Genetic variability and regression studies in chickpea (*Cicer arietinum* L.) and their implication in selection. *P.K.V. Research Journal*, 9(1) : 9-13.
- Kumar, J. 1989. Comparison of direct and indirect selection in chickpea (*Cicer arietinum* L.) Ph. D. thesis, IARI, New Delhi.
- Lal, S. Singh, S.N., Lal, S.B. and Tripathi, B.D.H. 1973. Improvement in gram through pedigree method of breeding. In : Proceeding of 10th workshop on rabi pulses, AICRPP (ICAR) held at Bose Institute, Calcutta, 10-14 September pp. 70-80.
- Mishra, S.K., Maurya, D.M. and Vishwakarma, D.N. 1991. Multi-trait selection during early generation selection in rice. *Indian J. agric. Sci.*, 61 (9) : 623-628.
- Yadav, S.S. 1986. Morphogenetic architecture of plant type in chickpea (*Cicer arietinum* L.). Ph. D. thesis, IARI, New Delhi.

IDENTIFICATION OF YIELD CONTRIBUTORS THROUGH PATH ANALYSIS IN MAIZE

ARUN KUMAR¹ AND N.N. SINGH

Directorate of Maize Research
Indian Agricultural Research Institute, New Delhi-110012

ABSTRACT

Path analysis was done in maize in order to identify the direct and indirect contributors of grain yield. Days to 50% silking and cob length had the maximum positive direct effect on grain yield at genotypic and phenotypic levels, respectively. On the other hand, days to 50% tasseling and silking had the maximum negative effect on grain yield at genotypic and phenotypic levels, respectively. Six characters had positive contribution to grain yield via a large number of characters both at genotypic and phenotypic levels. On the contrary, days to silking and maturity had negative contribution to grain yield via six characters both at genotypic and phenotypic level. On the basis of this information, the maize inbreds may be reconstituted for their further use in hybrid breeding programme.

Key words : Maize, path analysis, genotypic path, phenotypic path, causal factors.

Maize (*Zea mays* L.) is an important cereal crop which is grown in diverse agro-climatic conditions in India. It is grown both during rainy and winter seasons. In general, the yields from winter season crop are higher than those from rainy season crop. So far in this crop, the double and three way cross hybrids have become popular in the country, mainly due to cheapness of hybrid seed production. Though theoretically single cross hybrids are expected to give higher yield as they are hybrid in true sense, but theoretically single cross hybrids are expected to give higher yield as they are hybrid in true sense, but they could not become popular as their seed production is costlier on account of low productivity and poor performance of parental inbreds. In order to make seed production of single cross hybrids cheap, the improvement of the parental inbreds is a pre-requisite step. Before launching the improvement programme it is essential to identify the direct and indirect contributors of grain yield. Therefore, in the present study the efforts were made to identify the yield contributors through path coefficient analysis in 30 genotypes (7 inbreds and their 21 single crosses and two checks).

¹National Phytotron Facility, IARI, New Delhi-110012.

MATERIALS AND METHODS

The experimental material for the present study was comprised of seven inbreds and their 21 one way crosses and two checks (Ganga Safed 2 and DHM 103). These 30 genotypes were raised in a randomized block design in three replications at the Research Farm of Indian Agricultural Research Institute, New Delhi during 1999. The observations on 10 randomly selected plants in each genotypes were recorded on days to 50% tasseling, silking and maturity; plant and cob height; length and girth of cobs; number of kernel rows per cob; number of kernels per row; 100-kernel weight; and grain yield per plant.

The estimates of direct and indirect contributions on above ten traits on grain yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The total correlation coefficients between direct and causal factors do not reflect the complete view, specially when causal factors are inter-linked. Therefore, the total correlation coefficients between grain yield, a dependent

Table 1. Direct (diagonal) and indirect effects of 10 traits on grain yield of maize at phenotypic level

Characters	1	2	3	4	5	6	7	8	9	10	Total correlation with grain yield
Days to 50% tasseling	0.075	-0.165	0.067	-0.035	-0.034	-0.222	-0.145	0.009	0.032	-0.028	0.913**
Days to 50% silking	0.069	-0.180	0.065	-0.031	-0.031	-0.172	-0.127	0.010	0.027	-0.026	0.512**
Days to 50% maturity	0.039	-0.089	0.131	-0.004	0.000	-0.010	0.012	0.007	-0.001	0.026	-0.533**
Plant height	-0.040	0.083	-0.008	0.066	0.072	0.319	0.130	-0.001	0.051	0.067	-0.460**
Cob height	-0.035	0.066	-0.001	0.057	0.085	0.279	0.122	0.002	0.046	0.064	-0.460**
Cob length	-0.037	0.068	-0.003	0.047	0.052	0.455	0.145	-0.001	-0.054	0.063	-0.487**
Cob girth	-0.035	0.073	0.005	0.027	0.033	0.210	0.315	-0.016	0.024	0.059	-0.460**
No of kernel rows/cob	-0.024	0.064	-0.032	0.003	-0.005	0.023	0.184	-0.027	0.002	0.024	-0.322*
No. of kernels/row	-0.036	0.073	0.003	0.051	0.058	0.370	0.144	0.001	0.067	0.067	0.482**
100-kernel weight	-0.018	0.039	0.029	0.037	0.046	0.241	0.157	-0.005	-0.038	0.119	-0.234*

Residual = 0.293

* and ** denote significance at 5% and 1% levels, respectively.

Table 2. Direct (diagonal) and indirect effects of 10 traits on grain yield of maize at genotypic level

Characters	1	2	3	4	5	6	7	8	9	10	Total correlation with grain yield
Days to 50% tasseling	-1.628	1.330	0.233	-0.187	0.142	-0.098	-0.028	-0.079	0.173	-0.007	-0.495*
Days to 50% silking	-1.607	2.346	0.238	-0.170	0.113	-0.083	-0.024	-0.085	0.162	-0.006	-0.438*
Days to 50% maturity	-1.094	0.927	0.346	-0.031	0.004	-0.018	-0.006	-0.074	-0.008	0.008	0.054
Plant height	0.985	-0.742	-0.035	0.309	-0.267	0.142	0.026	0.011	0.270	0.014	0.712**
Cob height	0.800	-0.524	-0.005	0.285	-0.290	0.129	0.023	-0.017	0.255	0.014	0.671**
Cob length	0.841	-0.587	-0.033	0.230	-0.197	0.190	0.026	0.011	0.284	0.013	0.781**
Cob girth	0.864	-0.604	-0.042	0.153	-0.127	0.096	0.053	0.141	0.140	0.014	0.688**
No of kernel rows/cob	0.591	-0.531	-0.188	0.015	0.002	0.010	0.034	0.217	0.018	0.005	0.228
No. of kernels/row	0.858	-0.666	-0.008	0.254	-0.225	0.165	0.022	-0.012	0.328	0.015	0.730**
100-kernel weight	0.566	-0.413	0.127	0.201	-0.187	0.119	0.035	0.049	0.230	0.021	0.749**

Residual = 0.251

* and ** denote significance at 5% and 1% levels, respectively.

and compiled trait and other 10 characters were split into direct and indirect effects in order to examine their relative contribution. Hence the direct and indirect contribution of ten characters to grain yield obtained through path coefficient analysis at phenotypic and genotypic levels have been given in Tables 1 and 2, respectively and the results are presented as follows :

Phenotypic path

The data given in Table 1 suggested that at phenotypic level cob length had maximum positive direct effect on grain which was followed by cob girth, days to maturity and 100-kernel weight. On the other hand, days to 50% silking had maximum negative direct effect on grain yield. Days to 50% tasseling via cob length and girth; cob length via cob girth; cob girth via cob length; number of kernel rows per cob via cob girth; number of kernels per row via cob length and girth; and 100 kernel weight via cob length and negative effects on grain yield via most of the characters.

Genotypic Path

The data given in Table 2 suggested that days to 50% silking had maximum direct positive effect on grain yield at genotypic level which was followed by days to 50% maturity, plant height, number of kernels per row and number of kernel rows per cob. On the other hand, days to 50% tasseling had maximum direct negative effect, which was followed by cob girth.

Days to 50% tasseling via days to 50% silking; days to 50% silking via days to 50%

maturity; days to 50% maturity via days to 50% silking; plant height via days to 50% tasseling; cob height via days to 50% tasseling, plant height and number of kernels per row; cob length via days to 50% tasseling, plant height and number of kernels per row; cob girth via days to 50% tasseling, plant height, number of kernels per cob and number of kernels per row; number of kernel rows per cob via days to 50% tasseling, plant height and cob length; and 100-kernel weight via days to 50% tasseling and maturity, plant height, cob length and number of kernels per row had positive contribution to grain yield. Most of the traits had negative contribution via days to 50% silking and maturity and cob height.

It is interesting to mention that plant height, cob height, cob length and girth, number of kernels per row and 100-kernel weight had maximum positive contribution to grain yield via as many as 6 characters each out of 10 under study both at phenotypic and genotypic levels. Therefore, the yield may be manipulated by changing these 6 characters. On the contrary, days to 50% silking and maturity had negative contribution to grain yield by all these characters both at genotypic and phenotypic levels. This means by reducing the duration of silking and maturity most of these characters can favorably be improved and thus the grain yield can be improved. These findings would be of great help to the breeders for improving the inbreds of maize, which can further be used in synthesizing the high yielding single cross hybrids.

REFERENCES

- Dewey, D.R. and Lu, V.K. 1959. Correlation and path coefficient analysis of crested wheat grass seed production. *Agron. J.* 51 : 515-516.
- Wright, S. 1921. Correlation and causation. *J. Agric. Res.*, 20 : 557-558.

Short communication

EVALUATION OF ENRICHED PLANT RESIDUE COMPOST PREPARED BY UTILIZING PADDY STRAW AND BIOINOCULANTS

LIVLEEN SHUKLA AND RAJESH KUMAR

Division of Microbiology
Indian Agricultural Research Institute, New Delhi-110012

Compost making is the process of decomposing plant residues in a heap or a pit rather than in soil with a view of bringing the plant nutrients in more readily available form. (Gaur, 1990). Thus it prepares the food material outside the field and at the same time eliminates the unwanted readily oxidizable constituents of plant residues. If these residues are applied directly to the land without pretreatment they are likely to rob the succeeding crop of its soluble nitrogen. The quality of compost depends upon raw materials, composting methods employed and amendments to this experiment is to apply a battery of procedures for the assessment of compost stability and maturity.

An experiment was conducted in 1m³ cemented pits to prepare enriched plant residue compost using paddy straw as substrate. Unchopped and chopped straw (50 kg) was amended with rock phosphate (R.P.) @ 1% basis i.e., 0.2% and 1.0% P₂O₅ basis. The residues were inoculated with culture of *Aspergillus awamori* and *Azotobacter chroococcum*. Initial moisture was kept

at 100% level and later 50% level was maintained. The pits were filled with standard procedure and was allowed to decompose. The treatment schedule followed is given in Table 1.

The composting material was turned at every 15 days intervals. The samples were drawn at periodical intervals and were analysed for organic carbon, total nitrogen, total and available phosphorus.

The organic carbon content of the compost dropped to 35.2% and 36.8% in the chopped and unchopped straw controls showing a loss of 17.95% and 14.22%, respectively, during the first month of composting. Though, there was progressive loss of carbon with passage of time. The rate of decomposition decreased in subsequent sampling and decomposition rate and quantum was more with chopped paddy straw and higher level of rock phosphate showed more decomposition (Table 1).

The total nitrogen content (Table 2) increased appreciably in all treatments over the

Table 1. Changes in organic carbon (%) during production of enriched compost (average of 5 replicates)

Treatments	Sampling interval (days)		
	30	60	90
(T1) Chopped paddy straw (CPS)	35.2 (17.9)	30.6 (28.6)	26.0 (39.4)
(T2) CPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	30.7 (28.4)	28.2 (34.3)	25.0 (41.7)
(T3) CPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	28.8 (32.9)	25.1 (41.5)	23.7 (44.8)
(T4) Unchopped paddy straw - UCPS	36.8 (14.2)	34.1 (20.5)	31.8 (31.8)
(T5) UCPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	32.4 (24.5)	31.6 (26.3)	30.2 (29.6)
(T6) UCPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	30.1 (29.8)	28.8 (32.9)	26.6 (38.9)

Initial carbon = 42.9%

(value indicates % decrease over initial).

Table 2. Changes in total nitrogen (%) during production of enriched compost (average of 5 replicates)

Treatments	Sampling interval (days)			% increase in 'N' content over control
	30	60	90	
(T1) Chopped paddy straw (CPS)	0.81	0.99	1.30	0.00
(T2) CPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	1.21	1.43	1.72	32.3
(T3) CPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	1.26	1.53	1.78	36.9
(T4) Unchopped paddy straw - UCPS	0.79	1.20	1.26	0.00
(T5) UCPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	0.98	1.36	1.58	21.5
(T6) UCPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	1.08	1.56	1.72	32.3

Initial carbon = 0.49 (as amended C/N 60 = 0.71%).

Table 3. Changes in C/N ratio during production of enriched compost (average of 5 replicates)

Treatments	Sampling interval (days)		
	30	60	90
(T1) Chopped paddy straw (CPS)	43.1	30.9	20.0
(T2) CPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	25.3	19.7	14.5
(T3) CPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	22.8	16.2	13.3
(T4) Unchopped paddy straw - UCPS	46.5	28.4	25.2
(T5) UCPS + 1% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	23.0	23.2	19.1
(T6) UCPS + 5% R.P. + <i>A. awamori</i> + <i>A. chroococcum</i>	27.8	18.4	15.4

C/N ratio 87.6 (amended to 60).

Table 4. Available phosphorus during production of enriched compost (average of 5 replicates)

Treatments	Sampling interval (days)		
	Available - phosphorus (ppm)		
	30	60	90
T1	114.2	132.6	152.4
T2	218.4	195.8	240.3
T3	243.6	247.8	308.0
T4	108.6	120.9	139.8
T5	198.7	216.6	234.3
T6	239.1	267.3	289.2

initial nitrogen (0.71%) as amended to C/N ratio (60). The data on changes in C/N ratio (Table 3) showed the drop in ratio from treatments. The treated series showed a range between 13.3 and

19.1 for chopped straw and 15.4-19.1 for unchopped straw. The availability of phosphorus increased during the composting period in all the treatments including control (Table 4). And in the finished compost, the maximum available P (308 ppm) is with chopped paddy straw amended with 5% rock phosphate and microbial inoculants. Hence, all these tests have been suggested to evaluate the quality of compost.

REFERENCES

- Gaur, A.C. 1990. Organic manures, ICAR, New Delhi, 159 pp.
- Tiwari, V. 1989. Effect of cattle dung and rock phosphate on composting of wool wastes. *Biological wastes*, 27 : 237-241.
- Bhardwaj, K.K.R. and A.C. Gaur 1985. Recycling of organic wastes, ICAR, New Delhi, 104 pp.

Short communication

EFFECT OF INTERCROPPING AND INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF MUSTARD AND CHICKPEA

R. TIGGA, B.S. JOSHI, SANJEEV MALAIYA* AND G.K. SHRIVASTAVA

Department of Agronomy

**Department of Plant Physiology*

Indira Gandhi Agricultural University, Raipur-492012 (C.G.)

A field experiment was conducted at Instructional Farm, Indira Gandhi Agricultural University, Raipur on Vertisols with pH 7.5, EC 0.15 ds m⁻¹, organic carbon 0.67%, available N 320 kg ha⁻¹, P₂O₅ 12.00 kg ha⁻¹ and K₂O 580.00 kg ha⁻¹ under irrigated conditions during *rabi*, 1998-99. The experiment has twenty treatment combinations of five intercropping (I₁-sole mustard at 40 cm, I₂-sole chickpea at 30 cm, mustard + chickpea i.e. I₃, I₄ and I₅ in 1:2, 1:3 and 2:3 ratios, respectively) and four integrated nutrient management (F₁-recommended fertilizer dose i.e. RFD for mustard 80:50:30 and for chickpea 20:50:30 kg NPK ha⁻¹, F₂ - RFD + phosphorus solubilizing bacteria i.e. PSB, F₃ - 50% RFD + 50% N through FYM and F₄ - 50% RFD + 50% N through FYM + PSB) and were laid out in split plot design with three replications. Intercropping was assigned to main plots whereas integrated nutrient management was allocated in subplots. Pusa Bold cultivar of mustard and JG-74 cultivar of chickpea was taken as test crops.

Plant height of mustard and chickpea under various intercropping system was found significant at 60 and 90 DAS. The maximum plant height of mustard was recorded in sole mustard at 60 and 90 DAS. Significantly taller plant height in case of chickpea were recorded under mustard + chickpea (2:3) at 60 and 90 DAS. However, 1:2 and 1:3 ratios of mustard + chickpea were also found comparable. The number of branches per plant and dry matter accumulation in case of mustard was significantly higher under sole mustard at both 60 and 90 DAS. Significantly higher number of branches was recorded in sole

chickpea than other intercropping at 60 and 90. The maximum dry matter accumulation in chickpea was recorded in sole chickpea followed by mustard + chickpea (1:2) at all the growth stages. This may be probably due to more availability and efficient utilization of natural resources like light, nutrients and moisture etc. for growth. Similar results were observed by Kondap *et al.* (1985), Meena (1989), Patel and Patel (1991) and Mandal *et al.* (1994). Significantly, the highest seed yield of mustard was recorded in sole mustard as compared to mustard + chickpea intercropping in 2:3, 1:2 and 1:3 ratios. The highest yield may be due to more number of rows in sole mustard. Similarly under this treatment, plant growth and yield components were higher than rest of the treatments, which might have resulted in higher yield under sole crop. Similar observations were reported by Patel and Patel (1991). This might be the reason for reduction in yield of mustard when intercropped with chickpea. Seed yield of chickpea showed significant variation among intercropping treatments and the maximum seed yield was found in chickpea sole. Similar results were observed by Sachan and Uttam (1992).

As regard integrated nutrient management practices, growth parameters of mustard and chickpea viz., plant height, dry matter accumulation and number of branches were found to be maximum with 50% RFD + 50% N (FYM) + PSB followed by RFD + PSB. Similar results were reported by Patel and Meisher (1994) and Yadav Shrivastava (1996). It may be due to better nutrition of NPK through combined application of chemical fertilizer + FYM + PSB.

Table 1. Effect of intercropping and integrated nutrient management on growth characters and yield

Treatments	Plant height (cm)				Number of branches				Dry matter accumulation (g plant ⁻¹)				Yield (q ha ⁻¹)			
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C
Intercropping																
Sole mustard	115.37	-	154.23	-	16.04	-	22.38	-	29.74	-	46.93	-	11.06	22.31	-	-
Sole chickpea	-	35.86	-	42.04	-	13.18	-	16.27	-	6.67	-	16.95	-	-	13.48	18.95
Mustard+Chickpea(1:2)	110.66	36.61	146.03	44.25	14.73	11.36	18.61	14.89	27.96	5.44	44.64	14.81	7.26	18.42	8.10	14.87
Mustard+Chickpea(1:3)	109.72	37.00	144.66	45.10	13.73	10.60	17.87	13.61	24.60	4.53	40.46	13.63	6.47	19.03	9.32	16.29
Mustard+Chickpea(2:3)	109.39	38.75	143.68	46.90	13.55	10.25	17.47	13.26	23.08	4.42	37.51	13.04	8.16	19.74	6.34	12.95
SE _{mt}	0.30	0.35	0.33	0.31	0.15	0.18	0.19	0.28	0.23	0.32	0.23	0.37	0.18	0.23	0.03	0.25
LSD(P=0.05)	1.06	1.05	1.16	1.11	0.53	0.63	0.68	0.98	0.81	0.92	0.82	1.05	0.65	0.81	0.12	0.88
Integrated Nutrient Management (kg NPK ha⁻¹)																
RFD	109.21	35.25	143.23	41.83	12.67	10.62	16.80	12.74	24.29	4.29	40.35	11.77	7.34	20.66	8.34	16.19
RFD+PSB	112.13	38.28	146.03	45.49	14.94	12.62	20.79	14.49	27.10	6.38	43.34	15.66	8.41	19.50	9.67	15.62
50%RFD+50%N(FYM)	110.05	36.30	144.66	43.05	13.85	10.75	18.05	13.31	25.76	5.31	41.98	13.15	7.84	20.22	8.90	15.84
50%RFD+50%N(FYM)+PSB	113.75	40.49	154.68	48.52	16.20	13.39	23.68	16.78	28.22	7.27	44.86	17.86	9.36	19.12	10.33	15.40
SE _{mt}	0.29	0.38	0.30	0.45	0.33	0.30	0.32	0.29	0.30	0.26	0.32	0.28	0.32	0.31	0.30	0.26
LSD(P=0.05)	0.85	1.11	0.87	1.32	0.97	0.87	0.94	0.84	0.88	0.75	0.93	0.81	0.95	0.92	0.88	NS

M - Mustard, C-Chickpea, RFD - Recommended fertilizer dose (Mustard 80:50:30 kg NPK ha⁻¹ and Chickpea 20:50:30 kg NPK ha⁻¹), PSB - Phosphorus solubilizing bacteria, FYM - Farmyard manure, DAS - Days after sowing.

Similar trend was also noted for yield of mustard and chickpea. It may be due to the fact that application of recommended fertilizer dose along with FYM and PSB increases root growth as well

as root cation exchange capacity that enhanced nutrient absorption, plant growth and seed yield. Singh and Singh (1992) and Sachan and Uttam (1992) have also observed similar results:

REFERENCES

- Kondap, S.M., Rao, A.R., Mirza, W.A. and Bhojireddy, G. 1985. Intercropping in sesamum with legumes. *J. Oilseeds Res.*, **2**(2) : 124-128.
- Mandal, B.K., Choudhury, S.K. and Subuethi, U.K. and Dandapat, A. 1994. Growth and water use by yellow sarson (*Brassica campestris* sub sp. *oliefera* var. yellow sarson), safflower, chickpea and lentil grown as sole and intercrops with four moisture regimes. *Indian J. Agron.*, **39** : 386-391.
- Mena, S.L. 1989. Studies on nitrogen management in mustard, chickpea intercropping system under rainfed conditions. Ph.D. Thesis, IARI, New Delhi.
- Patel, R.S. and Meisher, T.G. 1994. Effect of farm yard manure nitrogen and source of fertilizer on growth, yield attributes and yield of Indian mustard. *Indian J. agri. Sci.*, **67** (6) : 237-240.
- Patel, R.S. and Patel, Z.G. 1991. Effect of organic, inorganic and biofertilizer on yield and quality of chickpea. *Indian J. Agron.*, **36** : 419-420.
- Sachan, S.S. and Uttam, S.K. 1992. Intercropping of mustard (*B. Juncea* L.) with chickpea (*C. arientinum*) under different planting systems on eroded soils. *Indian J. Agron.*, **37** : 68-70.
- Singh, M. and Singh, H.B. 1992. Effect of nitrogen and phosphorus on growth and yield of Indian mustard and chickpea in intercropping system. *Indian J. Agron.*, **42** (4) : 592-596.
- Yadav, R.P. and Shrivastava, V.K. 1996. Response of chickpea to phosphorus and biofertilizer. *Legume Res.*, **20**(2) : 137-140.

Short communication

LEAF GROWTH, CHLOROPHYLL, NITROGEN CONTENT AND GRAIN YIELD OF HYBRID RICE AS INFLUENCED BY PLANTING TIMES AND N LEVELS

A.K. VERMA, N. PANDEY AND R.S. TRIPATHI

Department of Agronomy
College of Agriculture, Raipur-492012 (C.G.)

Rice hybrid have potential to produce 10-15 percent more yield than inbred varieties (Li 1981, Yang and Sun, 1988). But, the agronomic strategy to achieve the target yield is yet not sufficient for different agroclimatic conditions of India. The effect of planting time on rice grain yield varied from one region to another. Nitrogen efficiency in hybrid rice is greater than conventional rice (Yang, 1987). Hence, an attempt was made to study the effect of planting time and N levels on growth parameters and yield of hybrid rice.

The experiment was conducted during 1998 at I.G.A.U., Raipur, Chhattisgarh. Three planting dates i.e., July 20, August 5 and August 20 were kept in main plots and each plot was further splitted into 3 subplots to put nitrogen levels (50, 100 and 150 kg ha⁻¹) for planting of 'Proagro 6201' rice hybrid during *kharif* season. Thus, 9 treatments were kept in split-plot design and replicated thrice. The soil was clay loam, having pH 6.8, organic carbon 0.42%, available nitrogen, phosphorus and exchangeable potassium were 210, 23 and 310 kg ha⁻¹, respectively. One third of nitrogen as per treatment and full dose of P₂O₅ and K₂O @ 75 and 60 kg ha⁻¹ were given as basal and remaining N was top dressed at maximum tillering and panicle initiation stage of the crop. Heat unit and correlation coefficient were calculated by using the method of Nagai (1962) and Miller *et al.* (1958), respectively.

The rice hybrid planted either July 20 or August 5 being at par produced significantly higher number of leaves and leaf area than August 20 planting (Table 1). Xie *et al.* (1996) also reported the reduction of leaf area, with delayed sowing of rice. Nitrogen concentration in leaf

decreased with an advancement of crop age, which might have been due to more dry matter yield. Earlier planting (July 20 and August 5) increased N content significantly in third leaf as compared to later planting (August 20) at 60 and 90 days after transplanting (DAT). Whereas, July 20 planting obtained maximum N concentration in third leaf at 30 DAT. Chlorophyll 'a', 'b' and total at 65 DAT were significantly higher on August 5 planting than other two planting dates (July 20 and August 20). Grain yield of July and August 5 was similar and significantly better than August 20 planting. More heat accumulation, number of leaves, leaf area and N concentration in third leaf might have favoured the higher grain yield in earlier planting than delayed planting of hybrid rice.

Number of leaves plant⁻¹ only upto 60 DAT, leaf area plant⁻¹, N content in third leaf at entire growing periods of plant and chlorophyll 'a' and total were significantly higher with increasing N levels upto 150 kg ha⁻¹. On the other hand, application of 100 kg N ha⁻¹ was found statistically similar to 150 kg N ha⁻¹ for grain yield of hybrid rice. Reduction of grain yield under higher N rate might be due to increased sterility percentage and decreased the percentage of ripened grain (Katayama *et al.*, 1990). Li *et al.* (1991) was also reported the slower grain filling with increased N rates.

The correlation coefficient analysis revealed that the leaf area had significant positive association with grain yield at all the stages of hybrid rice. Whereas, N content in third leaf, chlorophyll 'a' and total were also positively correlated with grain yield only in 5% level of significance (Table 2). On the basis of above

Table 1. Effect of date of planting and nitrogen levels on heat unit, number of leaves, leaf area, nitrogen and chlorophyll content and grain yield of hybrid rice

Treatments	Heat unit (°C)	No. of leaves plant ⁻¹	Leaf area plant ⁻¹ , cm ²			N concentration in third leaf, %			Chlorophyll content mg g ⁻¹ plant, 65 DAT		Grain yield q/ha			
			30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	Chl 'a'	Chl 'b'		Total Chl		
Date of plantings														
20 July	3698	35.74	50.38	45.78	546.47	1589.62	1445.33	3.49	2.58	1.27	0.62	0.56	1.18	59.29
5 August	3278	35.06	49.74	43.78	549.58	1564.70	1397.96	3.24	2.52	1.25	0.79	0.67	1.46	57.40
20 August	3061	31.50	46.37	31.17	470.47	1495.17	826.01	2.68	2.26	1.05	0.41	0.46	0.87	50.93
C.D. (P=0.05)	-	2.47	3.09	4.69	64.30	30.72	111.76	0.08	0.06	0.06	0.08	0.03	0.08	3.59
Nitrogen levels (kg ha ⁻¹)														
50		30.47	32.70	28.74	415.17	1434.04	880.20	2.96	1.92	1.05	0.53	0.44	0.97	47.57
100		34.46	49.71	42.78	518.07	1556.20	1258.29	3.17	2.68	1.22	0.61	0.61	1.22	58.75
150		37.37	58.04	45.23	634.38	1659.24	1530.81	3.29	2.78	1.30	0.67	0.64	1.31	61.30
C.D. (P=0.05)		2.39	3.34	3.59	58.84	93.85	87.46	0.06	0.09	0.04	0.06	0.08	0.09	4.03

Table 2. Correlation coefficient of grain yield of hybrid rice with leaf area, Chlorophyll content and N content in third leaf

Characters	Leaf area plant ⁻¹ , cm ²			N content third leaf, %			Chlorophyll content mg g ⁻¹ plant, 65 DAT		Grain (q ha ⁻¹)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	Chl 'a'	Chl 'b'		Total Chl	q/ha
Leaf area 30 DAT		0.84**		0.78*	0.43	0.61	0.69*	0.47	0.73*	0.63	0.81**
Leaf area 60 DAT				0.72*	0.41	0.66	0.55	0.43	0.62	0.55	0.80**
Leaf area 90 DAT					0.77*	0.65	0.66	0.77*	0.82**	0.85**	0.87**
N in third leaf 30 DAT						0.52	0.35	0.66	0.52	0.64	0.68*
N in third leaf 60 DAT							0.37	0.43	0.61	0.54	0.79*
N in third leaf 90 DAT								0.48	0.53	0.53	0.67*
Chl 'a' 65 DAT									0.73*	0.95**	0.60
Chl 'b' 65 DAT										0.91**	0.75*
Total Chl 65 DAT											0.71*

DAT - Days after planting; * and ** Significant at P = 0.05 and 0.01, respectively.

results we can concluded that the month of July is most favourable for planting of hybrid rice and application of 150 kg N ha⁻¹ increased the

growth parameters but ultimately grain yield was at par with 100 kg N ha⁻¹.

REFERENCES

- Katayama K., Song, X.F., Hiroto, O., Agata W. and Takeda, T. 1990. Sci. Bulletin Faculty of Agric. Kyushu Univ., **45**: 1-2.
- Li, Z.B. 1981. Beijing Agricultural Science and Technology Press, 186-187.
- Li, Z.L., Wu, Y.L., Xie, L.C. and Chen, Yo 1991. *J. South China Agric. Univ.*, 22-27.
- Miller, P.A., Williams, J.C., Robinson, H.F. and Comstock, R.I., 1958. *Agro. J.*, 126-131.
- Nagai, I. 1962. In fundamentals of rice crop science, Souchi Yoshida, IRRI, 45-46.
- Xie, Guanghui, Su, Baolin, Shi, lei, Tian, An You, Xie, G.H., SU BL, Shi, L. and Tian, A.Y. 1996. *J. China Agri. Univ.*, 89-94.
- Yang, X. 1987. Agric. Univ. Hangzhou, China.
- Yang, X. and Sun, X. 1988. In : Hybrid rice, Manila (Philippines), IRRI, 159-164.

Short Communication

RESPONSE OF RAGI VARIETIES TO NITROGEN UNDER RAINFED CONDITIONS

RAGHUVIR SINGH*

Hill Campus, G.B. Pant University of Agriculture and Technology
Ranichauri, Tehri Garhwal

Ragi (*Eleusine coracana* (L) Gaertn) is an important food and fodder crop occupying about 22.4 per cent of total cultivated area in Uttaranchal State. It is grown rainfed in "Ragi-Fallow-Rice-Wheat" rotation. The yield potential of Ragi under rainfed area has been very low because of practically negligible use of fertilizers, conventional cultivation of low yielding varieties and lack of good management practices. The productivity of Ragi can be increased through adoption of improved varieties and optimum nitrogen level (Rao *et al.*, (1989). Hence an attempt was made to study the response of medium duration Ragi varieties to nitrogen under rainfed condition.

A field experiment was conducted at G.B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, Tehri Garhwal during *kharif* season of 1998-99. Treatment consisting of six Ragi varieties (BM-1, GPU 38, BM 11-1, TNAU 889, HR 374 and VL 148) with three levels of nitrogen (20, 40 and 60 kg N/ha) were laid out in randomized block design with three replications. The soil of experimental field was silty clay loam in texture with pH 5.6. It was low in available nitrogen (230.0 kg/ha), phosphorus (11.8 kg/ha) and rich in available potassium (380.0 kg/ha). The crop was sown on June, 22, 1998 and harvested in the month of November, 1998. A uniform dose of 40 kg P₂O₅ and 25 kg K₂O was applied through Mussooriephos and Muriate of potash as basal dressing. Half of nitrogen was applied through urea as basal dressing and the remaining half was top dressed at tillering stage.

Out of six Ragi varieties tested, variety BM-

* Present address : S.V.B.P. Univ. of Agril. & Technology, Research Station, Ujhani, Budaun (U.P.).

1 produced higher effective tillers (36.1/m) followed by VL-148 and GPU 38. However, differences among the varieties in regards to effective tillers were not found significant (Table 1). Variety GPU 38 was taller (90.3 cm) than rest of the varieties. Varieties VL 148 and BM 11-1 matured 10 days earlier than varieties TNAU 889 and HR 374. As far as yield contributing characters are concerned, variety TNAU 889 recorded higher ear weight and grain weight/ear followed by variety GPU 38.

Variety TNAU 889 produced significantly higher grain yield (22.50 q/ha) than varieties BM 9-1, BM 11-1, HR 374 and VL 148, respectively (Table 1). Variety TNAU 889 gave 40.89, 3.83, 44.60, 21.20 and 11.84 percent higher grain yield than varieties BM 9-1, GPU 38, M 11-1, HR 374 and VL 148, respectively. However, the difference between variety TNAU 889 and GPU 38 was not found significant. The maximum yield of TNAU 889 may be attributed due to higher ear weight and grain weight and grain weight/ear. Similar trend was also observed in stover yield.

Application of nitrogen had significant effect on effective tillers and plant height (Table 1). The maximum effective tillers (38.0/m) and plant height (90.2 cm) were recorded with 60 kg N/ha. However, the difference between 60 and 40 kg N/ha in both the characters was not significant. The increase in nitrogen level from 20 to 60 kg N/ha increased the ear weight and grain weight/ear.

There was significant increase in grain yield with increasing nitrogen levels from 20 to 60 kg N/ha. The maximum grain yield (22.92 q/ha) was recorded with 60 kg N/ha which was 60.92 and 25.04 per cent higher than 20 and 40 kg N/ha,

Table 1. Yield and yield contributing characters of Ragi as influenced by nitrogen levels

Treatments	Effective tillers/m	Plant height (cm)	Days to maturity	Ear weight (g)	Grain weight/ear(g)	Grain yield (q/ha)	Stover (q/ha)
Varieties							
BM 9-1	36.1	83.9	143	3.05	2.24	15.97	75.83
GPU 38	35.3	90.3	143	3.50	2.55	21.67	91.30
BM 11-1	32.4	85.0	140	3.10	2.30	15.56	79.53
TNAU 889	31.5	80.9	149	3.86	2.82	22.50	93.97
HR 374	35.3	85.3	149	3.36	2.47	16.94	86.92
VL 148	35.4	81.6	139	3.30	2.46	18.33	88.67
C.D. (P=0.05)	NS	4.6	-	-	-	3.44	12.22
N levels (kg/ha)							
30	30.6	78.4	140	3.08	2.39	14.24	71.71
40	34.5	84.9	144	3.41	2.46	18.33	87.71
60	38.0	90.2	147	3.57	2.56	22.92	98.65
C.D. (P=0.05)	4.1	3.3	-	-	-	2.43	8.70

respectively. Similar results were reported by Jain *et al.* (1983) and Singh and Arya (1994). Application of 60 kg N/ha also gave higher stover yield which was 37.57 and 12.47 per cent than 20 and 40 kg N/ha, respectively.

REFERENCES

- Jain, V.K. Sharma, R.B., Jain P.C. and Chauhan, Y.S. 1983. *Madras Agric. Journal*, 70(5) : 333-336.
- Rao, K.L. Rao, O.P. and Rao, K.V. 1989. *Indian J. Agron.*, 34(3) : 302-306.
- Singh, R.V. and Arya, M.P.S. 1994. *Indian J. Agron.*, 39 (1) : 125-128.

Short Communication

IMPACT OF NUTRIENT MANAGEMENT PRACTICES AND SORGHUM BASED CROPPING SYSTEMS ON MICRONUTRIENT DYNAMICS IN VERTISOLS

SYED ISMAIL¹, G.U. MALEWAR AND M.H. LOMTE²

Department of Agricultural Chemistry and Soil Science
Marathwada Agricultural University, Parbhani, Maharashtra-431 402

Crop production under intensive cultivation without replenishment of requisite amount of nutrients led to negative balances in soils as observed in long term fertilizer experiments (Goswami, 1998). Further, yield reduction and nutrient deficiencies are evidenced in cereal-cereal system (Malewar *et al.*, 1999). No sufficient data on the impact of sorghum based cropping systems vis-a-vis nutrient management practices on soil available micronutrients are available. Thus, the present work is an attempt in this direction.

A long term field experiment was conducted on Vertisol (Typic Haplusterts) at Sorghum Research Station, Parbhani from 1991 to 1997 in rainfed condition on fixed site in split plot design with six main treatments of sorghum based cropping systems (S_1 : sorghum - cotton (year after year), S_2 : sorghum - pigeonpea (year after year), S_3 : sorghum + pigeonpea (3:3 intercropping with change in strip every year), S_4 : sunhemp - rabi sorghum (year after year), S_5 : green gram-rabi sorghum (year after year) and S_6 : sole sorghum (every year)] and four nutrient management practices as sub treatment [N_1 : recommended dose of fertilizer (RDF), N_2 : 50 per cent RDF + 5 Mg farmyard manure ha^{-1} (FYM), N_3 : 5 Mg FYM ha^{-1} and N_4 : absolute control] thus, twenty-four treatment combinations were replicated thrice. The initial experimental soil was clay in texture (54 per cent clay), moderately alkaline in reaction (pH 8.27) and normal in salt content (EC 0.21 dS^{-1}). The

Present address :

¹College of Agricultural Technology, Marathwada Agricultural University, Parbhani-431 402.

²Sorghum Research Station, Marathwada Agricultural University, Parbhani-431 402.

soil contained 43.2 g kg^{-1} free calcium carbonate, 4.8 g kg^{-1} organic carbon and 223, 11.4, 369 kg ha^{-1} N, P_2O_5 and K_2O , respectively. DTPA extractable Fe, Zn, Mn and Cu in the soil were recorded as 4.53, 0.92, 13.17 and 2.32 mg kg^{-1} , respectively. In every season chemical fertilizers were applied through straight sources at the time of sowing and organic manure (FYM) was incorporated in the soil in advance before sowing of the crop. Initially as a bulk and after completion of six rotations, the soil samples were collected from each experimental plot, processed and analysed by adopting standard procedures. Micronutrient determination was done as per method described by Lindsay and Norvell (1978) on atomic absorption spectrophotometer.

There was significant interaction effect of sorghum based cropping systems and nutrient management practices on the availability of micronutrient cations in soil after six rotations (Table 1). Significant buildup of Fe, Zn, Mn and Cu in soil was recorded in the treatment receiving 50 per cent RDF + 5 Mg FYM ha^{-1} (N_2) in sorghum + pigeonpea cropping system (S_3). On the other hand, maximum depletion in the content of DTPA extractable Fe, Zn, Mn and Cu in soil was noticed in sole sorghum without any fertilizer or manure (S_6N_4) treatment. In general sole sorghum was found very exhaustive crop followed by sorghum-cotton year after year under all the sets of nutrient management systems. Similarly, nutrient management practices particularly inclusion of FYM alone or its combination with inorganic fertilizer perform better in enhancing or maintaining the suitable levels of micronutrients in soil irrespective of cropping systems. Use of FYM helps to reduce fixation or precipitation because of its property

Table 1. Interaction effect of sorghum based cropping systems and nutrient management practices on DTPA extractable micronutrients

Cropping Systems	Nutrient management practices			
	N ₁	N ₂	N ₃	N ₄
DTPA Fe (mg kg ⁻¹)				
S ₁	4.30	4.45	4.37	4.22
S ₂	5.25	5.59	5.38	5.18
S ₃	5.52	6.22	5.84	5.39
S ₄	5.10	5.24	5.15	4.98
S ₅	4.76	4.93	4.82	4.59
S ₆	3.80	3.89	3.83	3.70
C.D. (P=0.05)	0.38			
DTPA Zn (mg kg ⁻¹)				
S ₁	0.95	1.09	1.04	0.83
S ₂	1.12	1.32	1.18	0.87
S ₃	1.21	1.41	1.32	1.12
S ₄	0.98	1.32	1.12	1.11
S ₅	1.01	1.26	1.09	0.78
S ₆	0.73	1.04	0.84	0.64
C.D. (P=0.05)	0.28			
DTPA Mn (mg kg ⁻¹)				
S ₁	14.20	16.56	15.66	11.65
S ₂	18.39	20.84	19.08	17.65
S ₃	19.39	24.34	21.69	18.21
S ₄	16.86	19.00	17.60	15.21
S ₅	16.52	18.08	16.82	15.86
S ₆	13.34	15.65	14.08	9.26
C.D. (P=0.05)	2.35			
DTPA Cu (mg kg ⁻¹)				
S ₁	2.32	2.58	2.40	2.25
S ₂	2.48	2.67	2.66	2.40
S ₃	2.53	2.78	2.68	2.41
S ₄	2.35	2.67	2.53	2.27
S ₅	2.32	2.62	2.49	2.18
S ₆	2.15	2.36	2.27	2.14
C.D. (P=0.05)	0.09			

changing strip every year also resulted in significant buildup of micronutrients under varied nutrient management practices. Root remaining and shredding of pigeonpea leaves probably added to the soil relatively in higher quantity as compare to other systems, recycled and decomposed and inturn increased the micronutrient cations in soil. In nutshell, intercropping of sorghum + pigeonpea (3:3) with 50 percent RDF + 5 Mg FYM ha⁻¹ would be a good practice for desirable maintenance of micronutrients in soil.

REFERENCES

- Goswami, N.N. 1998. *Bull. Indian Inst. Soil Sci.*, **2**, 3.
- Lindsay, W.L. and Norvell, W.A. 1978. *Soil Sci. Soc. Amer. J.*, **42**: 421.
- Malewar, G.U., Ganure, C.K., Rudraksha, G.B. and Syed Ismail. 1999. *J. Maharashtra Agric. Univ.*, **24**: 125.
- Mann, M.S., Takkar, P.N., Bansal, R.L. and Randhawa, N.S. 1978. *J. Indian Soc. Soil Sci.*, **26**: 208.

Short Communication

RESPONSE OF GREENGRAM TO SULPHUR AND ZINC

UMESH SINGH* AND D.S. YADAV

*Department of Agronomy
Narendra Deva University of Agriculture and Technology
Kumarganj-224 229, Faizabad (U.P.)*

A field experiment was conducted at the Agronomy Research Farm of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the summer season of 1995 to find out the optimum dose of sulphur and zinc for greengram. The treatments consisted of four levels, each of sulphur (0, 15, 30 and 45 kg/ha) and zinc (0, 5, 10 and 15 kg/ha). The experiment was conducted in a randomized block design with three replications. The soil of the experimental field was silty loam in texture having organic carbon 0.42% and N, P, K, S and Zn 110.28, 18.00, 140.42, 12.32 and 1.16 kg/ha, respectively with pH value of 7.8 and electrical conductivity of 0.24 dS/m. A uniform basal application of 100 kg diammonium phosphate per hectare was given to all plots. Sulphur and zinc were applied as per treatment in soil before sowing. The greengram cultivar 'Narendra Moong-1' was sown on 28 March, 1995. The seed was sown in rows spaced at 30 cm apart with a seed rate of 20 kg/ha. The crop was harvested on 6 June, 1995 when the pods matured and turned yellowish brown. The data on yield components and yield of greengram were recorded.

It is evident from the data presented in Table 1 that yield and yield attributes except pod length and number of grains/pod of greengram increased significantly with increasing level of sulphur upto 30 kg/ha. An increase of 20.55, 39.97 and 41.57% in grain yield and 17.95, 33.94 and 35.25% in straw yield was recorded due to 15, 30 and 45 kg S/ha, respectively over control.

Higher yield of greengram may be attributed to cumulative effect of higher values of yield attributes such as number of pods/plant, 1000 seed weight and seed weight/plant. The increase in these yield attributes under the influence of sulphur application might be due to the important role of sulphur in energy transformation, activation of enzymes and also in carbohydrate metabolism. The results are in close conformity with the findings of Jat and Rathore (1994) and Singh *et al.* (1994).

Increasing levels of zinc also increased the values of yield components except pod length and number of grains/pod greengram. Application of 5 kg Zn/ha gave the highest grain and straw yield which was significantly superior over control, 10 and 15 kg Zn/ha. Increase in zinc levels beyond 5 kg/ha resulted in significant reduction in the grain and straw yield. The increase in yield of greengram was 37.18, 20.54 and 11.24 per cent in grain and 31.21, 17.46 and 9.58 per cent in straw due to application of 5, 10 and 15 kg Zn/ha over control, respectively. Increase in grain and straw yields due to zinc application was due to cumulative effect of plant growth and yield attributes such a number of pods/plant, 1000 seed weight and seed weight per plant. Zinc plays an important role in the production of indole acetic acid, a growth hormone which results in higher value of auxin content which helps in increased growth of the plants and ultimately higher values of yield attributes and yield. These results confirm the findings of Ahmed *et al.* (1986). Kushwaha (1993) also reported similar results in urdbean. The reduction in yield at higher zinc levels might be due to deleterious effect of zinc on growth and yield attributes of greengram.

*Present address : Division of Tissue Culture, Defence Research Laboratory (DRDO), Post Bag No. 2, Tazpur-784 001 (Assam).

Table 1. Effect of sulphur and zinc on yield attributes and yield of greengram

Treatment	Pods/plant	Pod length (cm)	Grains/pod	1000-grain weight (g)	Grain weight/ plant (g)	Grain yield (q/ha)	Straw yield (q/ha)
Sulphur (kg/ha)							
S ₀	8.78	6.14	7.99	35.41	2.61	6.23	18.27
S ₁₅	9.84	6.40	8.31	36.40	3.24	7.51	21.55
S ₃₀	10.84	6.69	8.61	37.33	3.80	8.72	24.47
S ₄₅	10.93	6.72	8.64	37.40	3.86	8.82	24.71
C.D. at 5%	0.58	NS	NS	1.06	0.36	0.88	2.51
Zinc (kg/ha)							
Zn ₀	9.14	6.20	8.10	35.75	2.82	6.67	19.42
Zn ₅	11.20	6.84	8.72	37.67	4.01	9.15	25.48
Zn ₁₀	10.28	6.53	8.44	36.81	3.49	8.04	22.81
Zn ₁₅	9.77	6.38	8.29	36.32	3.18	7.42	21.28
C.D. at 5%	0.58	NS	NS	1.06	0.36	0.88	2.51

REFERENCES

- Ahmed, I.U., Rahman, S., Begum, N. and Islam, M.S. 1986. *J. Indian Soc. Soil Sci.*, **34**(2) : 305-308.
- Kushwaha, B.L. 1993. *Indian J. Pulses Res.*, **6**(2) : 152-154.
- Jat, R.L. and Rathore, P.S. 1994. *Indian J. Agron.*, **39**(4) : 651-654.
- Singh, S.K., Singh, R and Singh, S. 1994. *Indian J. agric. Sci.*, **64**(6) : 390-392.

Short Communication

TILLERING POTENTIAL OF SEMI-DWARF WHEAT VARIETIES UNDER TIMELY SOWN IRRIGATED CONDITION

U.K. BEHERA¹

IARI, Regional Wheat Research Station, Indore-452001 (Madhya Pradesh)

Field experiments were conducted in vertisols under irrigated conditions during rabi 1997-98 and 1998-99 in split plot design with four replications. The main plot treatments were two methods of sowing : spaced sowing with plant to plant and row to row distance of 50 cm and normal sowing of continuous rows 23 cm apart with a seed rate of 100 kg/ha for the seed weight of 38 g/1000 grains. In spaced sowing 5 seeds were dibbled at a spacing of 50 cm apart in each row. After 15 days of sowing, plants were thinned out to keep one seedling per hill. In the sub plot, twelve wheat varieties as listed in Table 1 were included. The recommended practices were followed for raising the crop. Tillers were counted from spaced sowing plots at 30, 40, 60 and 75 days after sowing. However, in normal sowing plots, seedlings at germination and productive tillers at maturity were counted. Besides grain yield per plant and grain weight per spike were recorded from all the treatments.

In spaced sowing, tiller production per plant at 30 days stage varied between 5.5 and 7.8. Tiller production at 40 and 60 days was nearly 3 and 6 times higher, respectively in all the cultivars in comparison to that at 30 days (Table 1). The maximum tillers/plant (46.18) were produced at 75 days after sowing, which varied between 38.2 and 55.8. Among the varieties HI 977 produced maximum number of tillers (55.8) followed by HI 1077 (52.3) and UP 2003 (51.8). The mortality of tillers varied between 2 to 26 percent. Varieties HI 977, HI 1077, CPAN 3004 and UP 2003 had maximum tiller mortality (15-26 percent). The varieties WH 542, MACS 2496, and PBW 222 had minimum tiller mortality (2 to 3 per cent).

Spaced sowing produced 42.81 productive tillers/plant which was significantly superior to normal method of sowing. From Table 2, it is very clear that the varieties which had potential to produce as many as 42.81 productive tillers under spaced sowing, produced only 1.55 tillers per plant when grown in community. This elasticity of varieties to produce productive tillers is because of community competition. Similarly, grain weight per spike and grain yield/plant were significantly higher spaced sowing comparison to normal line sowing. Comparatively a higher range of grain yield/plant in spaced sowing is attributed to higher number of productive tillers/plant and production of weighty spikes (Table 2).

The varieties differed significantly in producing productive tillers/plant and grain weight/spike. However, the grain yield/plant was non-significant among the varieties which showed that the varieties producing lower number of productive tillers could produce higher grain weight per spike, thus making the grain yield non-significant. Saini and Nanda (1979) also reported similar results. Variety GW 190 produced lowest (19.25) tillers per plant and produced highest grain weight (2.29 g)/spike. Variety PBW 222 produced highest (25.86) tillers per plant and its grain weight per spike was the lowest (1.84 g).

It is inferred that the wheat varieties have higher tillers producing capacity under isolation, which is squeezed in community. Spaced planting produced higher grains weight per spike and grain yield per plant in comparison to normal sowing. Plant can adjust itself to produce the number of tiller depending on space availability.

¹Division of Agronomy, IARI, New Delhi-110012.

Table 1. Tillering behaviour of some promising semi-dwarf wheat varieties under spaced sowing in irrigated timely sown conditions (pooled mean of two seasons)

Treatment	Tillers/plant				Productive tillers at maturity	Tillers mortality (%)
	30 DAS	40 DAS	60 DAS	75 DAS		
HI 977	6.6	23.1	43.6	55.8	41.0	26.5
HI 1077	7.1	24.4	45.5	52.3	44.0	15.87
HD 2329	6.6	20.9	32.8	43.1	40.0	7.20
HD 2402	6.1	16.8	29.0	39.7	37.0	6.80
CPAN 3004	6.2	18.0	34.8	47.4	38.0	19.83
DL 803-3	6.4	18.8	32.1	38.2	37.0	3.14
DWR 162	6.1	18.2	34.7	44.4	43.0	3.15
GW 190	5.5	17.8	31.0	39.2	37.0	5.61
MACS 2496	5.6	16.0	31.9	46.1	45.0	2.30
UP 2003	7.1	21.8	37.3	51.8	43.0	16.98
WII 542	6.6	21.0	40.0	47.3	46.0	2.75
PBW 222	7.8	22.7	41.5	48.9	46.0	5.9
Mean	6.47	19.96	36.18	46.18	41.42	9.67

Table 2. Effects of methods of sowing and varieties on productive tillers, spike weight and grain yield/plant (pooled mean of two seasons)

REFERENCE

Treatment	Productive tillers/plant	Grain weight/spike(g)	Grain yield/plant(g)
Methods of sowing			
Spaced sowing	42.81	2.52	107.61
Normal sowing	1.55	1.72	2.68
C.D.(P=0.05)	1.72	0.085	4.90
Varieties			
HI 977	21.06	2.09	53.59
HI 1077	22.67	2.06	58.22
HD 2329	20.91	2.03	50.46
HD 2402	23.44	2.24	63.46
CPAN 3004	19.68	2.19	48.62
DL 803-3	20.29	2.23	55.34
DWR 162	22.46	2.25	61.23
GW 190	19.25	2.29	49.91
MACS 2496	23.26	2.06	53.05
UP 2003	22.04	2.14	53.20
WII 542	25.22	1.97	58.72
PBW 222	25.86	1.84	55.95
C.D. (P=0.05)	4.32	0.124	NS

Saini, A.D. and Nanda, Rajender. 1979. The effect of culm number on yield in wheat. *Indian J. Plant Physiology*, 22(2) : 97-101.